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A Special Relationship

NOAA is fortunate in many ways, and one of the happiest is its closeness to the public it serves. Our agency is as close to the people as any Federal organization could be.

Our mission can be stated with a certain grandeur: we provide environmental management, research, and service from the sun to the seafloor and below. But perhaps a better perception of ourselves might be that we are at work in the American home, every day and every night, from the kitchen to the umbrella closet. Fish regulation and technology find an outlet in consumer education for the housewife (or housemate?). Our weather forecasts play a major role in many decisions, even when no natural disaster is imminent.

Along our coastlines, from Maine to the Gulf to the Northwest, and along the Great Lakes, in wetlands, beaches, fishing villages, ship harbors and sanctuaries, we are working to keep and properly use vital resources for our people. And past the coast, where ocean engineering and marine research come into their own, you will find NOAA at work.

There is no question of NOAA's relevance not only to the safety but to the quality of life in our country today. But what about tomorrow?

We are probing one mystery after another, asking questions whose answers hold fateful meaning for those who follow us. What's happening to the ozone, and what will it mean to humanity? What's happening to our environment as a result of carbon dioxide emission, and how much more can we take, and for how long? Will we be able to bend the weather, even slightly, to our will, and if so what are the implications? Will we be able to manage the world's fisheries in such a way that we can lessen the world's hunger, even a little? What will our planet be like a century or so from today, given certain kinds of climatic change?

This is the scene as we approach our seventh birthday, just around the corner in October. We have seven fast-paced, evolving years to look back on, an organization whose role is steadily growing, and a future bounded only by the limits of human imagination, drive and ability to.

The way to celebrate a birthday is with friends, and we do it with thousands of them every year. At facilities across the Nation, and on ships and planes, we open our working homes to the people we serve. We share our tools and techniques, our trials and our triumphs, and it is a warm and pleasant time.

And so it should be. For NOAA and the people of America have a special relationship.

Needed: A Global Priority List

OZONE: A CALL TO ACTION

By DONALD H. HUNT

SEVERAL scientific studies led in 1974 to a now-widely-accepted conclusion that the earth's vital stratospheric ozone shield is being destroyed by man through such otherwise acceptable activities as supersonic aviation, the use of nitrogen fertilizers, and especially the widespread use of chlorofluoromethanes (CFMs) in such applications as aerosol sprays and refrigerants.

Until that time, there was no general public awareness of the existence of an ozone layer which protects all living species by shielding out dangerous ultraviolet rays, much less that it was being threatened. To most people ozone meant a disagreeable component of urban air pollution—if it meant anything at all.

But the world quickly learned about this newest threat to our fragile environment, and during the first seven days in March of this year the largest international conference on this subject was held in Washington, D.C., to discuss the problem and proposed solutions.

NOAA and the Department of State co-hosted the meeting, which had been called by the Nairobi-based United Nations Environment Programme (UNEP). The session was convened by Dr. Mostafa Tolba, an Egyptian serving as Executive Director of UNEP, in response to a decision adopted by the Fourth UNEP Governing Council in May 1976. The chairman of the meeting was Dr. David Munro of Canada.

Representation was large and diverse. Delegates were present from 10 international, including non-governmental, organizations and 32 nations on six continents. These ranged from the industrial superpowers of the U.S. and U.S.S.R. to developing countries such as Togo, Libya, and the Central African Empire.

"We see our activities on the ozone layer," said Dr. Tolba in his opening address, "as an element in the assessment of outer limits, those . . . critical parameters whose maintenance is vital to the sustainability of the biosphere. The UNEP term, "outer limits," Dr. Tolba explained, is a shorthand expression for the concept that the biosphere, of which man is a part, can safely adapt to only a limited extent to the demands placed on it by man's activities. When these limits are transgressed, human welfare, even life itself, is threatened.

Dr. Tolba recalled that life on this planet became possible millions of years ago, when the atmosphere developed its thin, invisible but vital ozone shield, which reduces those wavebands of ultraviolet light from the sun harmful to the further development and sustenance of life.

Possible implications of reduction of the ozone layer, Dr. Tolba stated, beside increased incidence of skin cancer and effects on the world's climate, also include alteration of the rates of crop production, and reduction in the efficiency of natural water purification.

Dr. Tolba's urgent challenge to the meeting, therefore, was to review all aspects of the ozone problem; to identify future plans of action; agree on a division of labor among the international agencies, governments and non-governmental agencies, and on a coordinating mechanism.

UNEP's role, as catalyst and coordinator for dealing with environmental problems on a comprehensive, international basis, and providing leadership in developing the necessary responses, was recognized by NOAA Administrator Dr. Robert M. White in his welcoming address to the meeting, as being not only appropriate and significant, but perhaps critical.

He referred to the ozone layer as the "Achilles heel for man's impact on the atmosphere," because the threats are so complex and insidious. "No one nation can solve the environmental problems arising from man's capability to disturb the earth's upper atmosphere," White stated, "nor does any nation enjoy immunity from the possible consequences."

Even worse, the threat to the ozone layer has a wide time separation between cause (the release of oxides of nitrogen and CFMs into the atmosphere) and effect (the reduction of the ozone shield). "It is being suggested that we curtail certain important, economic, industrial and possibly agricultural activities now because later we will incur some very major penalties," Dr. White said, pointing out that knowledge of the basic physical processes expressed through mathematical models and computers is used to predict the effects. "These models and the conclusions depend rather critically on some very difficult measurements," he stated. "Some of which we have just begun to learn to make, and all of which are subject to uncertainty."

"This meeting," he continued "is an attempt to further our scientific understanding through international exchange of ideas and, we hope, to reach some views on what should be done by nations and by international agencies."

Most delegations had no difficulty in accepting Dr. White's characterization of this goal for the UNEP ozone meeting. The scientific characterization of the problem, although relatively recent, had been widely published. The World Meteorological Organization, one of the U.N. specialized agencies in attendance, had convened panels of experts in September 1975 and January 1976 to explore the ozone problem, and its findings and recommendations were presented to the meeting. The United States National Academy of

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Sciences had just completed an in-depth review of the scientific evidence against the family of halocarbons, published in 1976 under the title of *Halocarbons: Environmental Effects of Chlorofluoromethane Release*. And the United States Department of Transportation had completed a monumental study in December of 1974 of its four-year Climatic Impact Assessment Program, undertaken at the direction of Congress to ascertain the environmental impact on ozone and the climate of commercial supersonic aircraft operations, injecting oxides of nitrogen directly into the lower stratosphere.

Each governmental delegation reviewed recent scientific work in its country in order to present a summary paper at this meeting. The major halocarbon manufacturing nations had already been notified that the United States would be convening a separate meeting in late April to explore the question of regulatory activities, particularly the United States actions preliminary to promulgation of regulation, and to consider appropriate actions by all nations to establish the bases for worldwide regulation of chlorofluoromethanes.

Socioeconomic impacts of regulations were included on the UNEP agenda for discussion. However, the call for the meeting made clear that both scientific consensus and a national resolve in each nation would be needed for an in-depth evaluation of these problems and that a full consideration of these impacts was not expected at this time. Measured against the limited objectives established, the UNEP ozone meeting can be judged successful.

In addition to the wide representation, scientific research and monitoring activities were reviewed in detailed national summary reports from more than a dozen nations. Evaluation reports were presented by each of the specialized United Nations organizations. From these presentations, the meeting succeeded in defining high priority areas where more research and monitoring is needed. For each major research area, one of the U.N. specialized agencies was charged with responsibility for leadership and coordination. Finally, a Coordinating Committee on Stratospheric Ozone was recommended to be established as part of the UNEP organization, to provide at least annually a review of progress and recommendations to UNEP Governing Council for further actions required. These actions were incorporated in a world plan of action for presentation to the Fifth UNEP Governing Council meeting in Nairobi, Kenya in May 1977, for adoption and implementation by all concerned nations.

In view of the general agreement on the global nature of the problem, some concern was expressed over the lack of a consensus on the degree of urgency to be attached to the various national and international actions recommended. Perhaps the cautions voiced by a number of the delegates may be ascribed to one or more of three noticeable factors.

One was the deliberate reluctance on the part of the predominantly scientific delegations from the major industrialized countries to go beyond their available data and scientific expertise. There appeared to be a general willingness to defer political considerations, to be taken into account by the national delegations to the up-coming May meeting of the UNEP Governing Council.

A second was the restraint shown by consulate delegations in speaking on complex scientific issues. Third, a lack of prior documentation distribution to the countries and agencies inhibited the readiness of various delegates to make firm commitments.

The decisions of the Fifth UNEP Governing Council held in May 1977 provide some

NOAA Associate Administrator Dr. Edward Epstein, head of U.S. delegation, presents U.S. paper to conference (above, l. to r.): Dr. Alan Grobecker, National Science Foundation; Dr. Herbert Wiser, Environmental Protection Agency; Dr. Epstein; Paul Glasoe, Department of State. At left, Dr. Epstein and Conference Chairman Dr. David Munro of Canada present conference results at closing news conference. NOAA Administrator Dr. Robert M. White welcomed conferees on behalf of U.S.

evidence concerning the urgency ascribed worldwide to the ozone problem, but it is safe to say that the United States has taken a leading position in regulatory actions to date.

Since the United States produces only about half of the major CFMs involved, action by all the producer nations will be necessary in order to protect the ozone shield, and continued attention by UNEP will be necessary to provide the catalytic role which may be critical in bringing about a fully effective response from the producer nations worldwide.

Ultimately of course the World Plan of Action adopted by the UNEP Ozone Meeting depends on national research monitoring and regulatory efforts. This is true both for the efforts of the UN specialized agencies designated as lead action agencies, and for the UNEP as a whole. With hundreds of organizations involved, the value of the coordinating efforts of the specialized agencies and of the recommended UNEP Coordinating Committee on Stratospheric Ozone should not be underestimated.

Unfortunately, the World Plan of Action states that all of the recommended actions are considered to be of highest priority. Due to the sifting process by which these recommendations were developed, in the larger sense, this statement is true. But in terms of guidance for national action plans, a list consisting of all "highest priority" recommendations leaves to the mission interests of national agencies and research interests of individual scientists the order of selection of program areas for action.

As Dr. White pointed out in his welcoming address, the limited resources available for this global problem make it essential that these resources are applied first to the most important problems and that nations coordinate activities well. It will be the responsibility of the lead UN agencies to address the problem of limited resources and selection of priorities more concretely in undertaking the monitoring and research tasks specified in the plan.

Additional scientific evidence is required in three major areas, to each of which a section of the World Plan is devoted. As this evidence accumulates, it must be assessed by each nation, and, if appropriate, national actions taken in support of the objective of protecting of the Earth's ozone shield. Once regulatory actions have been taken, will the need for further monitoring and research under the World Plan of Action go away? The answer is no, at least for a relatively long time. Some of the impacts on the ozone layer are thought to be influenced by variations in the solar radiation. Monitoring will be required for at least one solar cycle of eleven years and more likely for two solar cycles. The year in which each country takes regulatory action will vary, and the impact of the resultant change will have to be assessed many times. Finally, the current position with respect to refrigerant uses, that is, that releases can be kept under control in closed systems, will have to be evaluated over a decade or more, or until an acceptable substitute system is found.

Under the first major section of the World Plan of Action, "The Natural Ozone Layer and its Modification by Man's Activities," attention is focused first on the need for development and implementation of improved systems for monitoring global ozone with sufficient accuracy to detect small but statistically significant long-term trends, the development of improved systems for measuring the intensity and spectral distribution of solar radiation, and for simultaneous measurements of selected species in the odd-nitrogen, odd-hydrogen and odd-chlorine families to provide the necessary data bases for better understanding of the photochemical processes involved.

The need for development of improved models to assess the interrelationships of chemical, radiative, hydrodynamic and thermodynamic processes controlling the troposphere and stratosphere, as well as improved accuracies in chemical and photochemical reaction rates and quantum yields for use in these models, is also recommended under Section I. All of these Section I recommendations call for the WMO to assume the leadership and coordinating role.

Section II deals with "The Impact of Changes in the Ozone Layer on Man, the Biosphere, and Climate." Among the recommendations, to be coordinated by WMO and WHO jointly with the Food and Agriculture Organization, were included the following:

- Monitoring of UV–B (ultraviolet) radiation at the Earth's surface for at least one complete solar cycle (11 years).
- Improved UV–B instrumentation.
- Statistics on Skin Cancer and Morbidity.
- Research on Induction and Repair Mechanisms, including synergistic and antagonistic factors.

Study of the effect of changes in UV–B radiation on various native and agricultural plants, animal species and microorganisms, on terrestrial and aquatic ecosystems and impacts on crop yields were designated as the lead responsibility for FAO.

WMO is charged with the leading role for developing improved climatic models and the data base for testing both global and regional climate models capable of assessing climate effects of stratospheric ozone changes.

Under the third and final section of the World Plan, "Socioeconomic Aspects" UN specialized agencies (OECD, ICC, ICAO and UNEP) are charged with the responsibility to develop more accurate data bases of production, emission and uses of substances that have the potential to affect stratospheric ozone.

Finally, upon the insistence of the Danish and Swedish delegates, this section charges several agencies, namely UNESA, OECD, ICAO, FAO, and WHO, with developing improved methodologies, including multidisciplinary systems analysis, for assessing the costs and benefits associated with various use levels of CFM's high-flying aircraft, nitrogen fertilizers and other potential modifiers of the stratosphere, whether controlled or not. This recommendation may be one of the most important in the entire World Plan of Action. For, as the UN Department of Economic and Social Affairs representative pointed out, negative or restrictive regulations may overlook important but relatively minor uses of CFMs, such as sterilization of hospital equipment, materials and surgical instruments; propellants for essential pharmaceutical applications; industrial cleaning of electronic equipment; and special situations for fire extinguishers where low-toxicity products leaving no residue are required, such as aircraft engines and computer mainframe units. Such essential uses may involve from two to five percent of total use of CFMs. In addition, the provision of refrigeration, essential for control of diseases resulting from food decay, must be evaluated in the broadest economic and social terms. The development of closed systems to prevent the careless release of CFMs to the atmosphere was suggested by the National Academy of Sciences study in connection with refrigeration uses, especially in connection with careless servicing of air conditioners which allows Freon to escape to the atmosphere.

Despite a lack of political unanimity, there is a sense of scientific urgency over ozone.

It is one of the trace constituents of the atmosphere. The total ozone layer, which absorbs most of the deadly ultraviolet radiation from the sun and thus makes life on earth possible, would, if reduced to standard sea level pressure and temperature, amount to a layer only about 0.3 centimeters thick.

Ozone is continually formed and destroyed naturally in the stratosphere. It is created when "odd" atomic oxygen (O), photodissociated from molecular oxygen (O_2) then combines with other molecular oxygen to form ozone (O_3). Atomic oxygen also destroys ozone. The rate of formation of ozone, which takes place predominantly in the upper stratosphere, is 5.0×10^{31} molecules sec^{-1} (integrated over the globe). Balancing this formation rate is the operation of the natural ozone destroyers. The odd oxygen system is responsible for destruction of about 20 percent of the ozone. The nitrogen (NO_x) system destroys over 60 percent. The hydrogen (HO_x) system wipes out about 10 percent. And the naturally occurring chlorine (ClO_x) systems destroy a minute portion. In addition, a small portion of the ozone is transported into the troposphere, where it is destroyed on contact with the earth. Thus the impact of injection of additional amounts of NO_x, ClO_x or HO_x into the stratosphere, increasing the rate of destruction, would be to tip the natural balance, causing a reduction of ozone, since there is no known mechanism to increase the rate of ozone formation in the upper atmosphere.

Observations during the early 1970s had shown increasing amounts in the troposphere of the most abundant CFMs, designated by their classification under the Dupont trade name of Freons as F–11 and F–12. The very chemical inertness of these compounds, which made them valuable as propellant gases in aerosol containers, as refrigerants and as foaming agents, now became a matter of concern. Was there any way in which these inert pollutant gases would be removed from the atmosphere?

The hypothesis that the only sink (removal processes) was photodissociation, and that

this photodissociation could occur only after the gases had been carried into the upper stratosphere above 20–25 km., was reached by three separate groups in 1974, Molina and Rowland at the University of California at Irvine, Stolarski and Cicerone at the University of Michigan, and Wofsy and McElroy at Harvard University.

Several disturbing features were hypothesized. The photodissociation of F–11 and F–12 would release chlorine atoms. Chlorine atoms would react with ozone in a fashion similar to the major nitrogen system, to destroy ozone. The chlorine reaction rate coefficient, however, would be about five times greater than the nitrogen reaction rate coefficient. In addition, the chlorine atoms were not immediately removed by the process, but freed to enter into the ozone-destroying reactions again and again.

How much chlorofluoromethane had already been released to the atmosphere? The DuPont Company attempted to assemble accurate worldwide data in 1974. The Environmental Protection Agency commissioned Arthur D. Little Company to perform an independent study in 1975. The State Department had undertaken an international estimate in 1975. Finally the international Manufacturing Chemists Association in 1976 undertook to compile data through an independent accounting firm, Alexander Grant and Co., to overcome the reluctance of manufacturers to release production data directly to their competitors. The answers began to establish the scale of the total problem. From the date when F–11 and F–12 was first introduced in the 1930's through 1975, total world production amounted to over 3.4 million metric tons of F–11, and over 5 million metric tons of F–12. The Manufacturing Chemists Association study concluded that over 85 percent of F–11 and over 86 percent of F–12, had been allowed to discharge into the atmosphere. The accumulated total, if all this material were still present in the troposphere, would correspond to an average concentration of 129 parts per trillion by volume (pptv) of F–11 and 220 pptv of F–12. The concentrations actually measured in the troposphere are from 60–110 percent of these values, which with some known and some unknown uncertainties, tends to support the scientific concern.

Are F–11 and F–12 found in the stratosphere, and more important, if they are, did their concentrations fall off above 20–25 kilometers as the photodissociation hypothesis requires? A number of measurements by different techniques in 1975 showed that these compounds are present in the stratosphere. Furthermore, the rates at which their concentrations decrease with altitude in the stratosphere above 20 km is consistent with the hypothesis that photodissociation is the dominant loss process for CFMs in the stratosphere.

The National Academy of Sciences estimated in its 1976 review of the environmental effects of chlorofluoromethane release that if CFM production continued at the 1973 rates the result after a few decades would be to decrease the total ozone shield by about 7.5 percent, with a ten-fold range of uncertainty about this central value, that is, the reduction may range anywhere between 2 and 20 percent. The decrease in ozone at the higher levels (say at 40 kilometers) may be as much as 25 percent, with smaller decreases at lower altitudes in the stratosphere. Even after a total cut-off of CFM emissions, the NAS found, ozone reduction continues for ten years, and then requires an additional 65 years to regain one-half of its maximum loss.

The resultant increase in damaging ultraviolet reaching the earth could involve, the National Academy report stated, increased incidence of malignant melanoma, a serious form of skin cancer frequently causing death, increased incidence of basal- and squamous-cell carcinomas, and effects on plants and animals of unknown magnitude.

Biological effects occur due to cell absorption of increased ultra-violet radiation in the UV–B spectral region (290–320 mm). Changes in the protein and nucleic acids in the cell alter the ability of these macromolecules to properly perform their biochemical functions, to the detriment of the living system in which they reside. The NAS report concluded that "unchecked CFM release would hardly seem prudent in view of our current inability to assess the ultimate consequences."

Climatic changes are a distinct possibility in connection with changes in the stratospheric temperature and ozone layer, although "neither the net direction nor the exact magnitude of this change can be predicted," the NAS report concluded. Models indicate that stratospheric temperature changes, induced as a result of the decrease of the ozone concentration, may not significantly effect tropospheric temperature. However, climatic simulation models are too rudimentary today to establish long-term effects of the mechanisms involved, and continued research is needed.

The direct effect of increased CFMs in the stratosphere would be to trap outgoing atmospheric radiation, which would be additive to similar effects from increasing carbon dioxide and water vapor, keeping the earth warmer by the greenhouse effect. Since the CFM effect at continued 1973 production rates could produce changes as large as observed natural variation over 100 years, intensive research through improved modelling is needed. The derivative effects of climatic changes constitute one of the major foci of concern in the ozone problem.

All in all, the pervasiveness of man's technology in every area of life is exemplified by the ozone problem.

Over the next century, as Dr. White reminded the delegates, the International Council of Scientific Unions Sub-Committee on Problems of the Environment (SCOPE) has pointed out that the proportionate influence of man and of natural processes on the Earth will continue to change in the direction of human dominance over environmental processes. If so, must not man share the responsibility to develop increasingly effective measures to counter adverse effects as his technology develops? Otherwise, the ozone problem may indeed become the Achilles' heel of the atmosphere. □

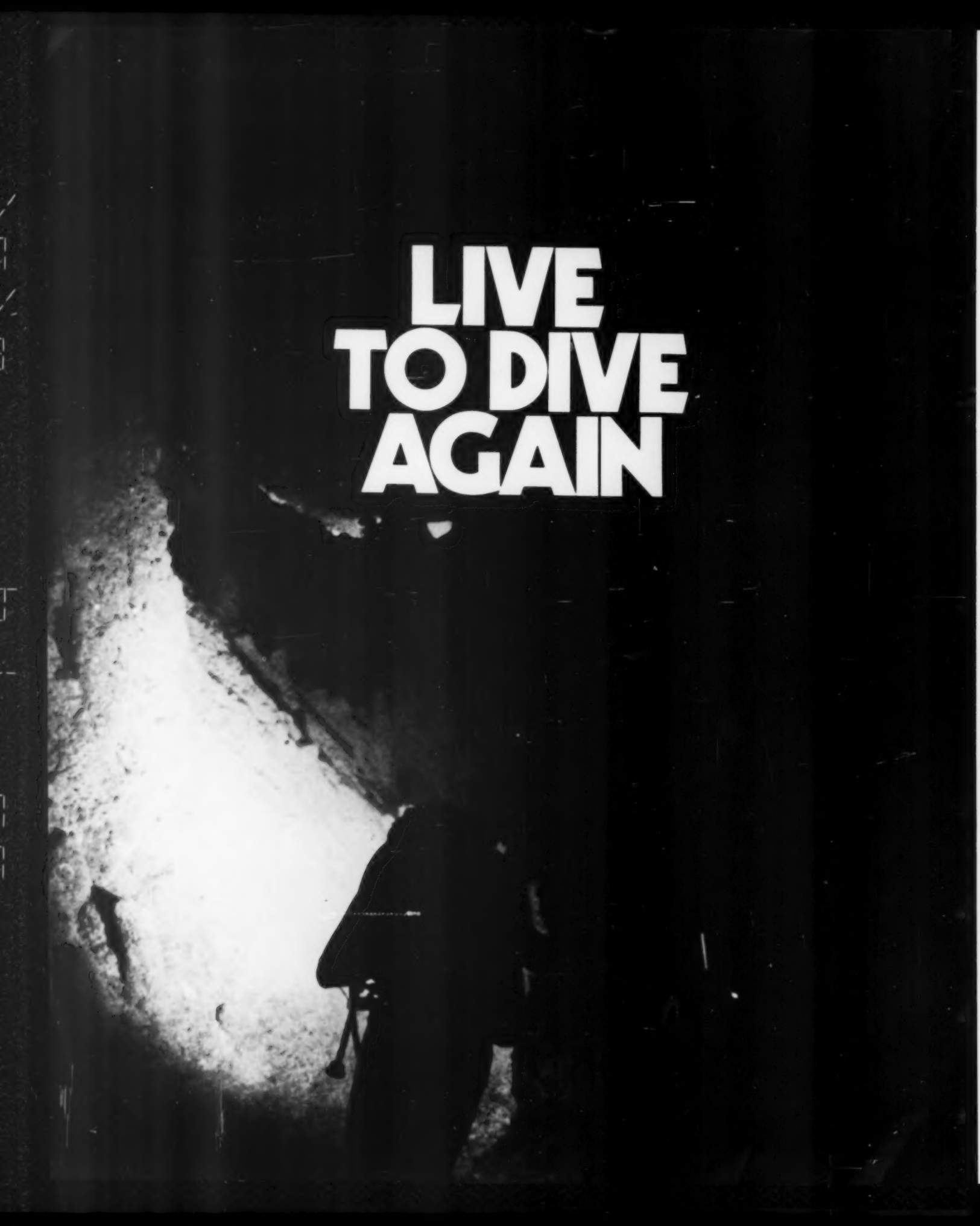
Fluorocarbons To Be Banned From Aerosol Spray Cans

Photo: Ed Horsmon, NOAA

A plan for banning some fluorocarbons, including chlorofluoromethanes and Freon in aerosol sprays within two years was announced jointly by three Federal agencies on May 11, 1977. The Food and Drug Administration, Environmental Protection Agency, and Consumer Product Safety Commission proposed a three-stage phaseout. Manufacturing fluorocarbons for the aerosol market would cease by Oct. 15, 1978. Companies would not be permitted to use fluorocarbons for spray can propellant after Dec. 15 of that year, and cans containing the gas would not be able to enter the market after April 15, 1979.

Regulations requiring spray cans containing fluorocarbons to bear labels to that effect after Oct. 31, 1977 were issued by FDA in April.

Officials of the regulatory agencies estimate that 60 percent of all fluorocarbon emissions in the U.S. will be eliminated as a result of their action. Aerosol propellants in 1973 accounted for 55 percent of fluorocarbons uses worldwide, and the U.S. produced about half of the total world output. However, less than 30 percent of the U.S. aerosol products now use fluorocarbons according to an industry group.


LIVE
TO DIVE
AGAIN

BENEATH THE WATERS lies another world; an awesome world, spectacular in its brilliance of color, mysterious in its content. A world inhabited by gracefully moving fishes, by strange crawling creatures. As foreign to many as the surface of a far off planet.

This other world—perhaps the final frontier on Planet Earth—represents to an estimated two million U.S. residents a new, enticing playground. Recreational scuba divers, they have sampled the delights of joining the underwater world, even if only for brief periods of time.

It's all so easy. Shrug the air tanks up onto your shoulders, don the other equipment needed, bite down on the mouthpiece, pull down your face mask, and slip quietly beneath the surface through a magical doorway to the other world.

But wait a minute:

Entering the world beneath the waters is not all that easy to do—safely. It is a matter of careful training, intimate knowledge and understanding of equipment, and constant awareness of numerous external factors, any one of which may pose a danger.

This is the warning sounded by the Manned Undersea Science and Technology Office of the National Oceanic and Atmospheric Administration; diving can be fun—but it also has its dangers.

The Commerce Department agency, which has—from its over 400 certified divers—more than 200 continually active divers handling highly specialized undersea assignments from the tropics to polar regions, is concerned with diving safety, both with its own and with recreational divers.

Statistics show that diving is continually becoming safer, but every year more than 100 needless fatal diving accidents still occur.

Dr. James Miller, Deputy Director of the MUS&T Office, says many fatalities could have been avoided had the divers observed the simple, common sense rules most of them had been taught.

Miller and his colleague, NOAA Diving Coordinator Dr. J. Morgan Wells, are particularly concerned for those who think scuba diving would be fun, but want to try it out before making a financial investment in proper training or equipment; and for novice divers who have just completed a training program and may be over-confident.

"It is absolutely foolhardy to dive without professional training," Miller says. "Too much can happen too quickly under water, sometimes without the first-time diver even being aware of it until it's too late. For example, the physiological stresses imposed upon a human body under water require compensation by the diver; deliberate changes in the way the diver carries on such ordinary functions as breathing." The diver should be aware of this, and should practice under controlled circumstances to avoid serious problems.

The same applies to equipment, Miller and Wells say. Without adequate training, a prospective diver easily could end up under water with equipment he or she doesn't know how to use properly, or the wrong kind of equipment.

Training sessions, too, emphasize the importance of divers being in good general health and alert the healthy diver to the fact that there are times, regardless of his or her

general physical condition, when diving should not be done. A diver can rupture an eardrum from diving with a head cold, while diving with a chest cold can lead to the occurrence of a deadly air embolism.

Miller and Wells recommend that anyone considering scuba diving sign up for courses offered by such organizations as the National Association of Skin Diving Schools (NASDS), the National Association of Underwater Instructors (NAUI), the Professional Association of Diving Instructors (PADI), Scuba Schools International (SSI), or the YMCA.

As with most other active outdoor sports, diving demands continuous, careful attention to every detail, not only before and during, but even after the dive, the two experts say.

Perhaps the most important detail they see, after training and equipment knowledge, is that of knowing where help can be quickly found should an accident occur.

Experience also teaches a diver to recognize his or her personal diving capabilities and not to go beyond them. According to Wells, "A" number of diving accidents each year occur precisely because of ignorance, carelessness, or overconfidence. These were primary factors in the majority of over 30 cases involving sport divers treated at NOAA's Miami recompression facility."

The wise diver knows that special training, and in some instances special equipment, is needed for diving in caves, under the ice, in heavy surf, and in lakes high up in the mountains where U.S. Navy Standard Air Decompression Tables do not apply because of the altitude.

Knowing conditions in the waters where you'll be diving is every bit as important as knowing your equipment, according to Wells, one of this country's most experienced divers. Such factors as depth, bottom conditions, tides, surf, currents, and marine animals likely to be in the waters are all considered by the good diver before he breaks the surface, going in.

Pollution in the water is another factor; of such importance that NOAA is planning to conduct a special polluted-waters diving study because some of its divers are called upon to perform research in heavily contaminated areas.

Fortunately, the sport diver need not venture into such dangerous waters. The 200,000 new divers who receive training each year have a wide choice of sites, each with its own particular interest or beauty.

The key work in diving, Wells and Miller agree, might be "awareness"—awareness not only of the surrounding beauty, but also the diver's vulnerability in this unfamiliar medium. The experienced diver is acutely aware of what is happening—both in the nearby water and in his or her own body. And when an unexpected event does occur, this alertness can provide a once-in-a-lifetime thrill, or be a lifesaver. The need for caution and concern remains when the dive ends. The diver must be on the lookout for any unusual physical sensations, and must know what to do about them—knowledge learned through training.

Every twist of conversation with Miller and Wells ultimately, it seems, leads back to the immense importance of professional training.

"There is a large body of knowledge available relating to safe diving," Miller says. "Much of it, of course, is common sense, like not flying immediately after diving. If you think about it, it's obvious. But will the new

Photo: John Roseborough, NOAA

Rescue diver training class (above) on the shores of Chesapeake Bay learns how to splint "broken arm" before moving the victim. At right, scuba divers enjoy swim along the bottom.

diver think about it? Probably not. That's one of the real values of professional training programs; the material presented has been carefully organized to permit the maximum of information to be provided the student; information that without a doubt can make a difference between an exhilarating experience and a fatal accident.

One aid to having fun under the water and still staying safe is the NOAA Diving Manual, available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, at $8.55, Stock Number 003–017–00283. □

First steps to scuba fun

How Do I Start?

How good a swimmer should I be if I want to take up scuba diving?
Moderately good, and you should feel at home and confident in the water.

What should my physical condition be?
You should have good general health and undergo an annual diving physical.

Can I dive if I have sinus congestion?
It is unsafe to dive either with a sinus or head or chest condition.

Do I have to be a skin diver before I can start scuba training?
No, but it helps. Basic skin diving skills are normally learned during the early phases of scuba diving.

Do I need formal instruction? Where can I get it?
Formal instruction is absolutely necessary for safe diving. For information contact the Council for National Cooperation in Aquatics, 220 Ashton Rd., Ashton, Md. 20702.

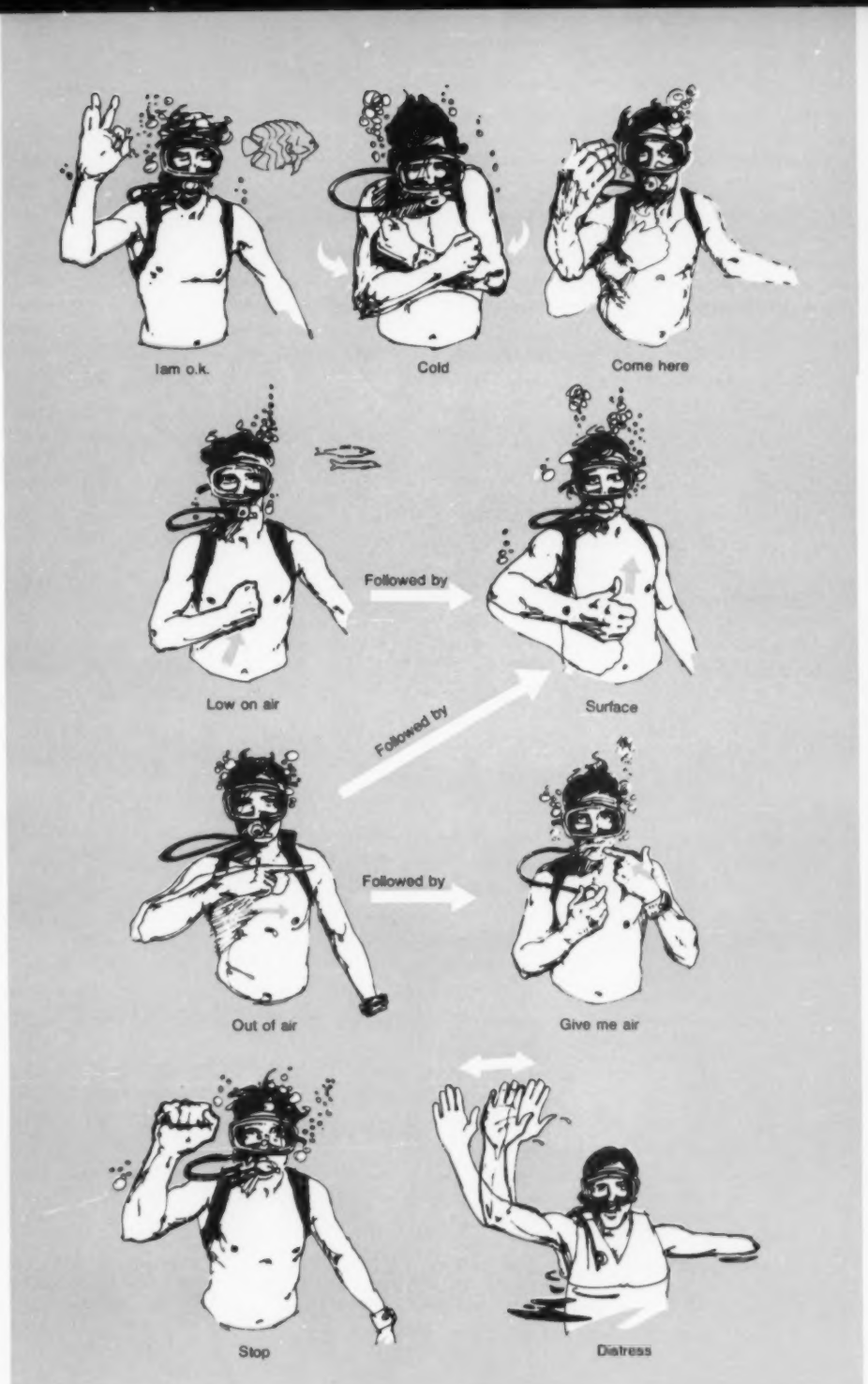
What does it cost to get started?
Costs for instruction normally are between $25 and $100, while basic equipment is from $200 up.

Does surface weather affect diving?
Environmental conditions do. One must consider wave and surf conditions, wind velocity, water and air temperature, surface and water visibility, and many other factors.

Can I go down by myself?
You should never dive alone. Your buddy may be essential in the event of difficulty.

Is it easy to get air for a scuba tank?
Yes, at most dive shops and compressed gas dealers, but to do so you should have (1) a certification card showing you've had accredited training, (2) a tank which has a current visual inspection sticker and an authorized hydrostatic test.

How many dives can I make each day, how long can I stay down, and how deep can I go?
Frequency of dives is most often limited by tolerance of fatigue and cold. The NOAA Diving Manual gives rules on depth, duration, and frequency of dives. This information may also be found in the U.S. Navy Diving Manual as well as many popular books on diving.



If something goes wrong while I'm under water, is there any chance of survival?
Yes, chances of survival are extremely high if you can apply emergency procedures learned during training.

Are under water cameras easy to use, and what do they cost?
Yes. With a minimum of training and a little experience, underwater photography can be a delight for an initial cost of under $100.

How can I communicate with someone else under water?
The simplest means is by hand signals. You can get attention by striking your tank with something hard. Sound travels well under water.

What do I do if I see a shark?
DON'T PANIC. Excited movements can attract sharks. Swim in a normal manner, and quietly leave the water.

What are the most important things to remember while diving?
If you have an emergency, stop, breathe easily, think, get control, then take action.

NOAA Seafloor Investigation

WHAT PRICE MANGANESE?

By LOUISE A. PURRETT

Color photography by Friedrich Hoelzl

THIS autumn may mark the beginning of a new technological age, when the ocean floor's mineral riches finally come within mankind's grasp. The first deep ocean mining systems, designed to reach down through miles of water to scoop up manganese nodules from atop the sediments, will be tested this year.

But what will be the cost of this new power? There are hundreds of millions of dollars, yen, or other currency that the industries of many nations have invested in designing, building, and testing the rugged equipment needed to accomplish the task. But there may be other costs, yet to be tallied or even identified. So while industry has been working out its problems, scientists with the National Oceanic and Atmospheric Administration have been trying to make an accounting of the other costs—to the environment.

The effort is called the Deep Ocean Mining Environmental Study (DOMES). From three years of research at three sites representative of those to be mined, DOMES scientists have arrived at some estimates of the environmental costs, estimates that will be tested soon as pilot mining ships move out into the Pacific and begin collecting manganese nodules. With the cooperation of the corporate miners, NOAA scientists will be monitoring some of the tests of mining systems, measuring the immediate and estimating long-term changes that take place in the environment.

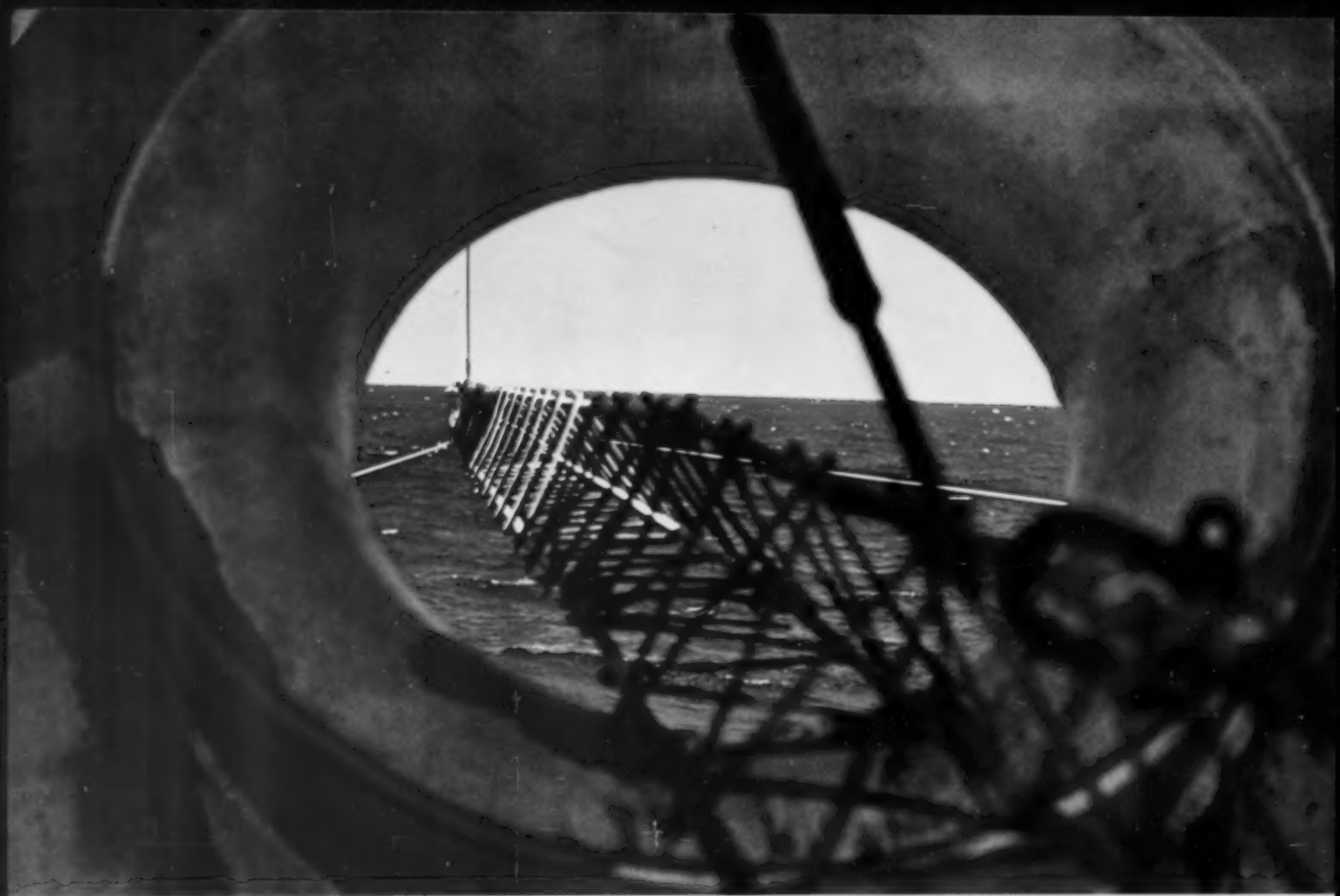
Manganese nodules, the focus of all this attention, are roundish rocks ranging in size from a pea to a softball and containing potentially commercial concentrations of manganese, cobalt, nickel, and copper. They have been found in both the Atlantic and Pacific, where they lie temptingly visible on top of the sediments. Pacific waters cover vast fields of them, in a zone 900 miles (1,400 kilometers) wide, extending 4,000 miles (6,400 kilometers) from Mexico to the Marshall Islands.

DOMES I scientists from NOAA and universities used the heavy, elaborately cabled devices of oceanography, such as this beefy grab sampler, to extract the ocean's key quantities.

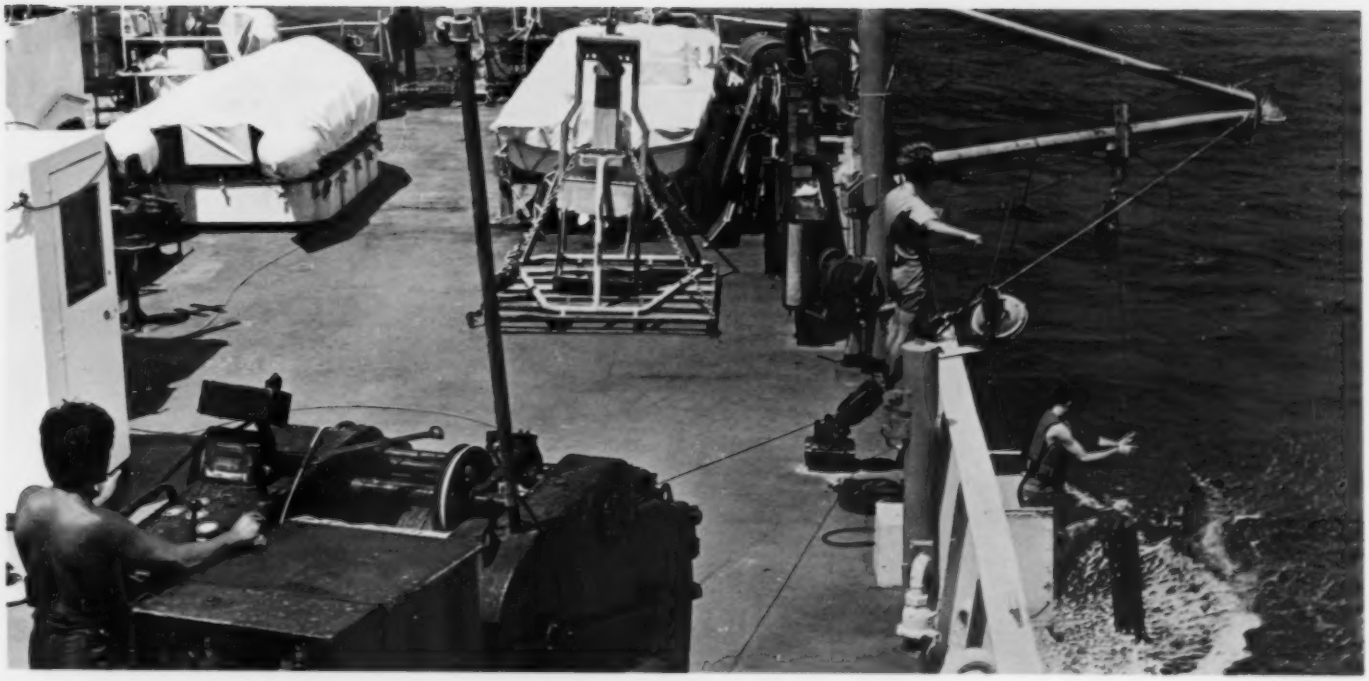
The DOMES project, part of the Marine Ecosystems Analysis program office of the Environmental Research Laboratories, has focused for the first two years of its existence on baseline studies—studies of the pre-mining state of a part of the nodule zone.

Scientists at another of the Environmental Research Laboratories, the Pacific Marine Environmental Laboratory in Seattle, conducted much of the actual research. Working with colleagues from a long list of universities and other institutions, they made exhaustive surveys of three sites within a 5-million-square-mile (13-million-square-kilometer) area of the central Pacific, where the nodules are richest, and where mining will begin. The three sites were selected as typical mining sites representative of the range of environmental conditions that mining might affect.

DOMES I took the NOAA ship Oceanographer on sorties into the Pacific some 2,000 miles southeast of Hawaii. From this floating laboratory an ocean-going buoy is deployed with a string of current meters and a colorful necklace of "Viney floats" to measure physical processes from deep in the ocean to the air-sea boundary. Above, Rick Miller of the University of Washington makes last minute adjustments on a current meter before it goes over the side.

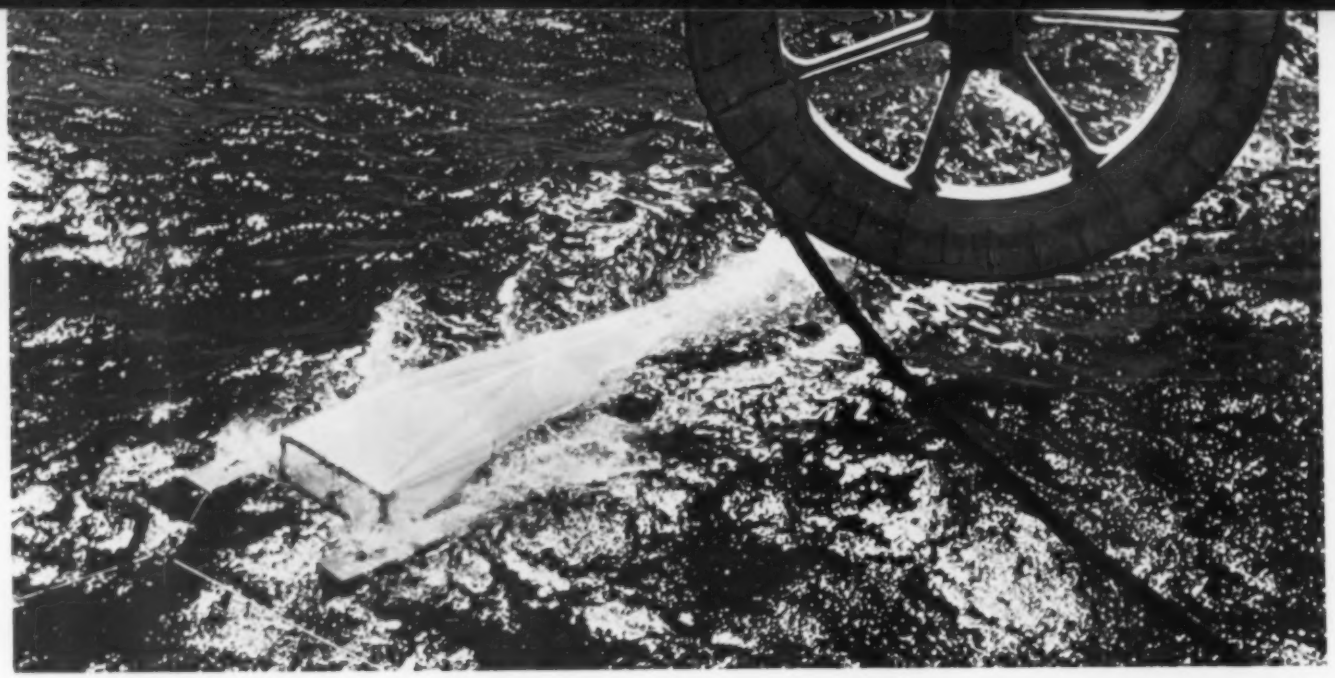


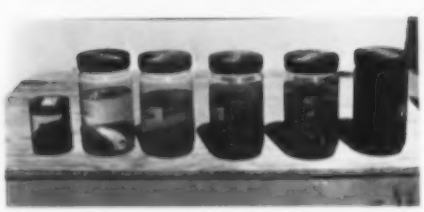
At the sea-air boundary, measurements of such parameters as sunlight and wind speed – things of the air – were as important to the scientists as those from the deep ocean. Solar radiation is measured from a boom and its downward-looking sensor poking from the bow of the Oceanographer. Above and right, a malfunctioning anemometer brings out a repair crew in the ship's Zodiac launch for a quick fix. The fixers, perched atop the buoy, are the University of Washington's Rick Miller (left) and the Oceanographer's Executive Officer, Cdr. William Curtis.

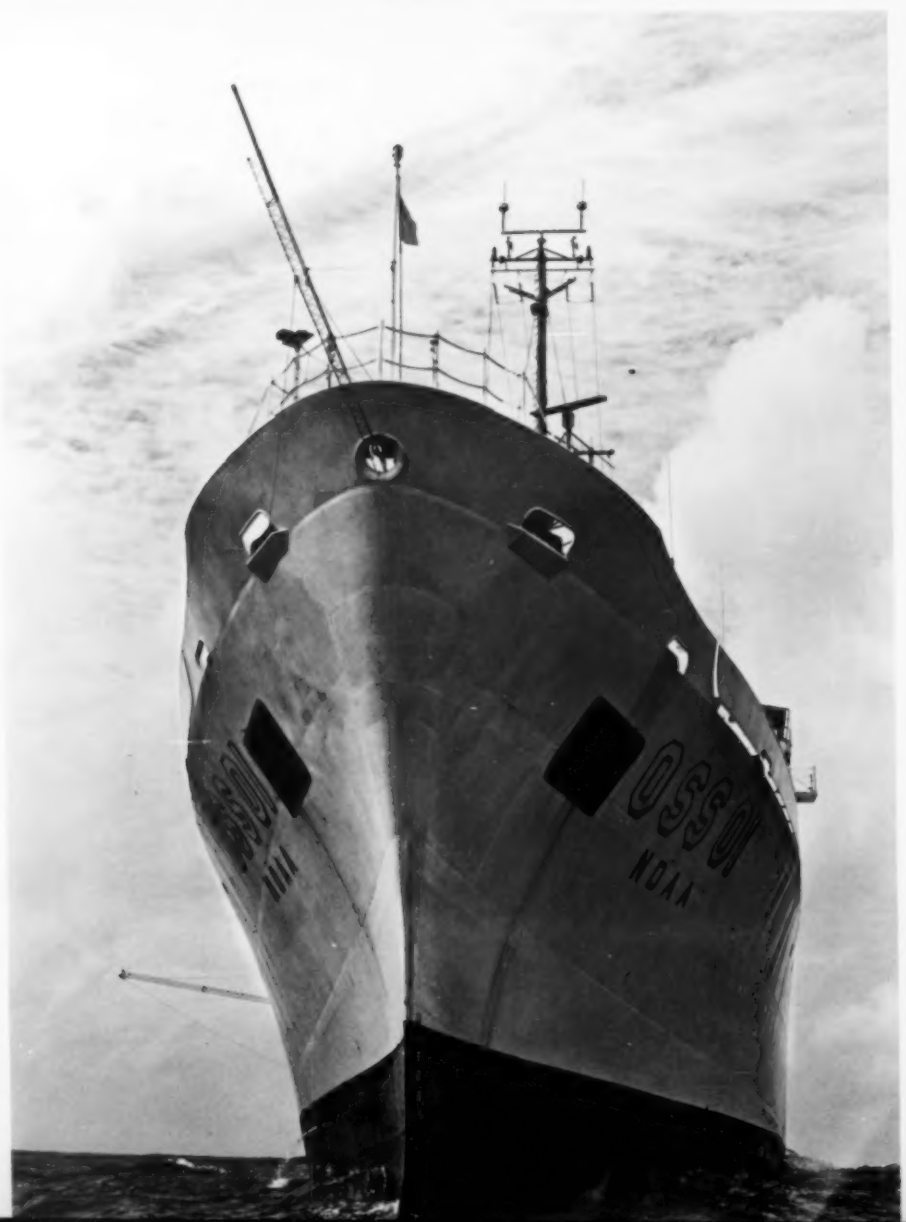


Sea water samples were taken from the surface to the ocean's floor during DOMES. At left, Judy Nevins of the University of Washington analyzes particles trapped by filters as the samples were decanted.

In another experiment made during DOMES, Bob Warren, (above) of Texas A&M University prepares a sample of sea water with Carbon 14 which is set adrift (left) by Susy Cassaro and Kurt Buck, also of TAMU, with mauve buoys to determine the samples' primary productivity in the open sea.







The DOMES baselines also sampled tiny drifting plant life – phytoplankton – and some larger forms to determine populations and what the probable impact of deep ocean mining will be on these Pacific life forms (above). Bongo nets deployed from the Oceanographer's stern (middle) collected samples as did surface skimming trawls (top) and larger nets that dragged the middle depths of the sea.

In a series of voyages at different seasons of the year, they made physical, chemical, and biological studies—collecting water samples to analyze for chemical traces; measuring salinity and temperature at selected depths; observing the phytoplankton, zooplankton, fishes, and crustaceans; collecting samples of sediment and nodules from the bottom; mapping currents; recording meteorological conditions, and scanning the sea floor with sonar and underwater camera.

From the data they have collected the scientists came to the tentative conclusion that, though mining might have drastic effects on the environment, it is possible that these effects would be short-lived and localized, soon swallowed by time and the vastness of the ocean.

A progress report issued recently summarized the results to date. In the report, the nodule area is described as one of clear, biologically productive waters. Measurements of light scattering and transmission showed that sunlight striking the surface of the sea penetrates to a depth of over 330 feet (100 meters). Only small amounts of fine particles, mostly of biological origin, cloud the water.

Between the two major currents of the area, one flowing east, the other west, is a divergence zone, where adjacent water masses are moving apart. This divergence zone, running east-west at about nine to ten degrees north latitude, influences the depth of the mixed layer, the upper layer in which such water properties as salinity and temperature are mixed homogeneously. At one site, the researchers found an unexpected deeper current, between 660 and 990 feet (200 and 300 meters) down, that flowed in the opposite direction from the westward-flowing surface current. The deeper current was more sluggish, but the speed of both varied greatly with time.

The upper layer of the water is low in nutrients, but nearly saturated with oxygen. Below the thermocline, however, different conditions prevail. There, a layer of water, in some places more than 1,640 feet (500 meters) thick, has very low oxygen concentrations. Deeper still, oxygen increases again. Near the bottom, the amount of dissolved oxygen in the water decreases steadily from west to east, while the nutrients form an opposite pattern, increasing from west to east. These opposing oxygen and nutrient trends imply that the bottom water is flowing eastward.

Clay, and a chalky ooze rich in tiny fossils, make up most of the sediments in the area.

Biological studies showed a great diversity of phytoplankton (tiny plant) species and a wide variation in the amounts of chlorophyll *a*, an index of biological productivity. Most of the zooplankton (microscopic floating animal life) live in the upper 660 feet of the water, probably because the oxygen-depleted layer acts as a kind of floor, keeping them above it.

The waters above the mining area are also commercial fishing grounds, especially for tuna. The commercial catch in 1973 amounted to 79,500 metric tons of tuna, 5,600 tons of billfishes, and 9,000 tons of shark. The total stocks of the area are probably twice these amounts. The total catch each year is worth about $82 million.

Photographs of the bottom showed that four groups of animals—sea urchins, brittle stars, anemones, sea cucumbers—make up 80 percent of the megafauna (creatures large enough to be picked up in the hand). In a few locations, bait was dropped near the camera and one, in 19,700 feet (6,000 meters) of water, attracted more than 40 large fish and shrimp.

With such a picture of conditions in the nodule area, the scientists were able to make some estimates of how the type of mining system planned might affect it.

The type of system that most deep sea miners are developing, says Dr. Robert Burns, the Pacific Marine Environmental Laboratory scientist who directs DOMES, is hydraulic. In it, a collector, or dredgehead, travels along the sea floor, sucking in nodules, surface sediments, and whatever else lies in its path, and pumping them to a ship at the surface. Effluents will be discharged at the bottom in a benthic plume, and at the surface.

Such mining ships will each recover 5,000 to 10,000 metric tons of nodules a day. They will be operating 24 hours a day, about 300 days a year. By 1985, two to four mining units are expected to be operating, recovering a total of 3 to 6 million metric tons of nodules annually.

To recover 5,000 tons of nodules, the scientists estimated, a mining system would have to skim the top from 222 acres (0.9 square kilometer) of ocean floor and compact 50 acres (0.2 square kilometer) under its treads.

With the nodules, the scientists estimated, the mining system would also suck up 36,000 tons of sediment, 1,727 pounds (783 kilograms) of living plants and animals, and 3,530,000 cubic feet (100,000 cubic meters) of water. A sediment rejection system near the sea floor would spurt most of this back into the lower layer of the sea.

At the surface, however, there will be additional discharge: 1,000 metric tons of sediment, 50 metric tons of abraded nodules, 51 pounds (23 kilograms) of biota, and 706,200 cubic feet (20,000 cubic meters) of water.

The DOMES progress report estimated that particulate matter brought to the surface by mining would greatly reduce light penetration into the upper waters, light necessary for photosynthesis. But within 24 hours, the water would have cleared enough for productivity to return to about half normal levels, and only the water in the immediate vicinity of the ship would be affected, anyway. Zooplankton and fish stocks might also decrease temporarily within a small area near the ship.

Any changes in water temperature, salinity, dissolved oxygen, and most nutrients in surface waters, the DOMES scientists believe, will be so small they will be difficult even to measure, and would have no detectable short-term effect on living organisms.

The sediment particles may also clog respiratory and feeding appendages of zooplankton, and some particles would inevitably be eaten. Fish might have trouble breathing if they remained in the area, but upper-water fish, at least, would probably simply leave, the DOMES report said. Ingestion of nodule material by zooplankton could introduce heavy metals into the food chain, but as yet it is not known how small these nodule particles would be and how much of this material would be eaten. Those are questions this summer's research may answer.

The life forms in the water will, in turn, affect the discharge, perhaps inadvertently cleansing the waters. If filter-feeding organisms eat suspended particulate matter, the sediments would thus be incorporated into fecal pellets, which would sink much faster than the finer sediments. The researchers believe this may be an important mechanism for removing sediments from the upper water.

These findings have had a dual effect. One result has been to make it all the clearer that monitoring of tests is necessary. "The chance, however small, of detrimental effects, and the many questions yet to be answered," says John Padan of NOAA's Office of Marine Minerals, "made it crucial to monitor these tests." Test monitoring would also become important when in the future some government agency is given responsibility for licensing or regulating deep ocean mining by U.S. firms. Padan points out that there is no way to arrive at sensible regulations unless the effects of mining are known.

Another result of the DOMES baseline studies has been development of preliminary guidelines that industry might follow to minimize the chance of adverse effects. A group of NOAA scientists from DOMES, the MESA program office, the Fisheries Service, and the Pacific Marine Environmental Laboratory made a list of such guidelines, which are to be published

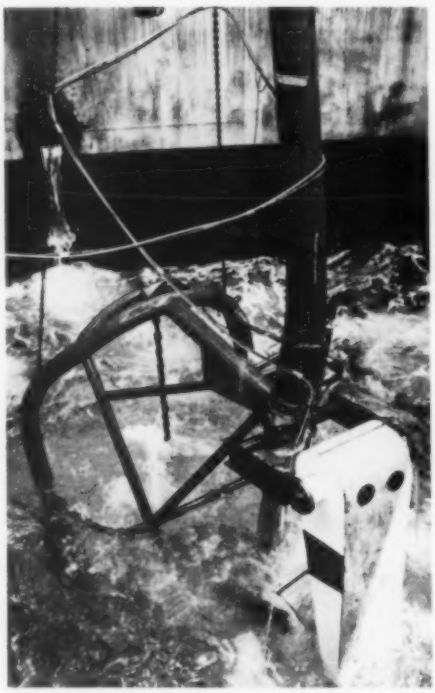
in the near future. These are very preliminary, emphasizes Padan, and they are only in the form of suggestions; "They have no teeth."

One guideline relates to discharges into surface waters. "It looks as if this might not be a serious problem," says Padan, who was a member of the guidelines group. "But we were trying to look toward deep ocean mining's maturity, when many ships might be operating simultaneously, raising the possibility of a buildup of particles in surface waters."

Possible effects of surface discharges that the group considered are: effects of sediment materials on the food chain, ultimately affecting commercially important species, such as tuna; long-term, chronic exposure of the biota to heavy metals from the nodules; and stimulation of bacterial growth by adding certain mining materials to the oxygen minimum zone, causing, in turn, depletion of oxygen or formation of poisonous hydrogen sulfide.

If future events show that adverse effects could occur, the task force suggests that an alternative disposal method might be considered. For example, the discharge might be released well below the surface—perhaps 1,000 meters down, to avoid the oxygen minimum zone. Or, the effluent might be retained on the mining vessel.

"There will be damage to benthic organisms; there's no way around that," continues Padan. And it appears from the study so far that disturbances at the ocean bottom will have little if any effect on the surface. But another suggestion for the miners is to try to minimize the dispersal of the benthic plume—something industry is already trying to do.



The mining site itself should also be selected with a view to potential adverse effects, the group continued; some areas are more vulnerable than others. For example, currents might exist that could carry mining wastes long distances, toward coral reefs at Hawaii or other islands. Or the area might be a breeding ground for tuna, or lie along fish migration routes or major shipping routes.

The DOMES scientists plan to monitor four mining tests over the next two years, says Burns. These tests have been scheduled by four different mining consortia. The first test they will monitor will be by Deepsea Ventures, Inc., the operational arm of Ocean Mining Associates.

The firm has already run some preliminary tests of the equipment, says Vice President Raymond Kaufman. The DOMES scientists will be monitoring one of the final tests, a pilot run in which the mining ship, R.V. Deepsea Miner II, will actually dredge up tons of nodules, as if it were in commercial operation. The Miner, Kaufman explains, is a converted ore carrier that is being used to test the feasibility of deep sea mining. During the pilot test, it will be pumping up nodules at roughly one-fifth the rate planned for a

Television technique for deepsea mining (above); TV camera, lights, and sample basket are lowered to ocean bottom on tripod. Specially designed dredgehead (right, top) is lowered through ship's moon pool, well cut amidships on oil rigs and drilling vessels where drill pipes are lowered; so-called because moon lights up pool pleasantly on calm evenings. Right, Deepsea Ventures pilot ming ship R/V Deepsea Miner II.

Photos by B. J. Nixon, Deepsea Ventures Inc.

commercial ship. The Miner is an interim ship, being used to verify the system and test the design for the larger commercial ships yet to be built.

"We've considered these environmental concerns to be very much a cooperative effort between us and NOAA," says Kaufman. He points out that whether commercial mining actually takes place is still "touch and go," and will depend on the economic feasibility of the operation, yet to be established. The economic feasibility will depend in part on the environmental studies, and on the regulations that may be imposed to protect the environment.

From the NOAA ship Oceanographer, from Deepsea Ventures' Miner, and the firm's exploration ship R.V. Prospector, NOAA scientists will conduct a 10- to 20-day study of the planned test area, to compare its characteristics with what was learned at the baseline areas. For another two days, they will re-examine the nearest baseline site, to see if any of its characteristics have changed since it was last studied.

Then, for 20 days, the NOAA scientists plan to monitor the actual mining tests. During the first test, says Burns, they will concentrate on the surface plume. Scientists aboard the mining ships plan to note how, where, and how rapidly effluents are discharged into the sea; the nature of the effluent—its temperature, salinity, concentration of solids; and, finally, what is done with the nodules that are collected or discarded.

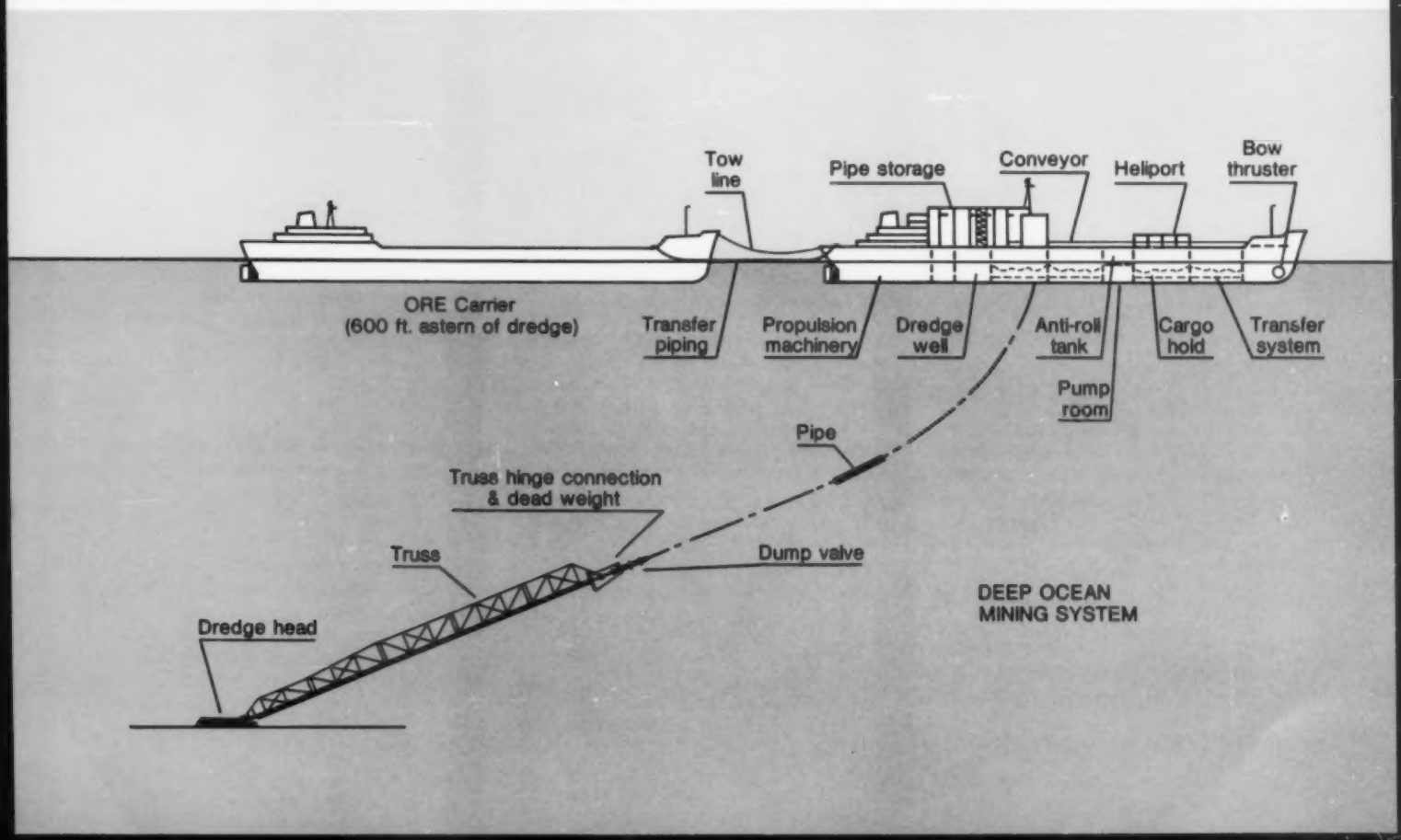
From the Oceanographer, they want to track the surface plume as it leaves the mining ship, making many of the same measurements they made during the baseline studies. They will attempt to define the growth of the plume in three dimensions, by collecting water samples and analyzing them for telltale traces of effluent material, making measurements of the clarity of the water at different places, and probing the water with sonar. They may also add a dye tracer to the effluent to make it more obvious. The scientists hope to supplement their ship-based observations with satellite images. Researchers will also study plankton to determine short-term effects of mining on the biota.

Long after the mining test has ended, the DOMES research will continue, watching the site to see how it recovers, and how long the process takes. The NOAA vessel will remain for three days after the end of the test, to monitor the site's immediate recovery, as the sediments settle again to the bottom or are dispersed by the currents. After a port call for reprovisioning and refueling, they will return to the site for a 20-day followup study.

Complete recovery of a mining area, including return of bottomdwelling animals, may take a long time. The DOMES scientists hope to return to each test site at intervals for as long as possible.

On later mining tests, the DOMES scientists hope to add a second research ship to observe events on the ocean floor as well as at the surface. They believe two ships will be necessary because underwater currents could well carry the bottom plume in a different direction from the surface plume. This second ship will track the bottom plume and monitor the effects of the dredgehead, observing how rapidly it moves across the bottom, how its movement clouds the waters, and how deep a scar it leaves. In addition to the same observations used to track the surface plume, the scientists will collect bottom samples, and lower underwater cameras for a visual record.

From all these studies, the scientists are seeking two key pieces of information: how many nodules each mining system recovers, and how much of the environment is disturbed in the process. All the environmental impacts must be evaluated in light of this knowledge, for this is what determines the social cost of a ton of manganese nodules. □



Photos by B. J. Nixon, Deepsea Ventures Inc.

Photo: Carl Mydans

Life on the Razor's Edge

DON GILMAN: FAR-OUT FORECASTER

By EDWIN P. WEIGEL

Dr. Donald L. Gilman, Chief of the National Weather Service's Long Range Prediction Group, and his Deputy, Robert Dickson, were among the most sought-after men in the entire NOAA family during the long, cold winter of 1976–77.

Says Gilman: "Because of the abnormally cold autumn and winter of 1976–77, the energy crunch, and the extreme drought in the Far West, our unit had more media exposure during these past seasons than in all the years of the group's previous history combined.

"Beginning about the end of November, and reaching a peak in January, we had about 15 'live' or videotaping sessions with major television networks, numerous interviews with local television and radio stations, and approximately 50 interviews of varying degrees of depth with wire service, newspa-

per and magazine reporters–not to mention several appearances before Congress."

Dr. Gilman and his six staffers routinely put out two major products: "The Average Monthly Weather Outlook," for the 30-day period ahead, issued shortly before the first and middle of each month, and a seasonal or 90-day average temperature outlook, issued at the end of each November, February, May, and August.

Unlike the more-familiar shorter-range weather forecasts, which extend out only a day or two, or at the most five days, with predictions of degrees of temperature and approximate amounts and kinds of precipitation, the 30-day outlooks are estimates of whether the weather will be colder or warmer than normal or wetter or dryers than usual during the period ahead.

The 90-day outlook ordinarily is for temperature only.

For the 30-day outlook, maps with contour-like lines are shown, indicating, first, whether the anticipated temperatures for various parts of the nation will be above or below normal, or near normal; and, second, on a similar map, whether various areas are expected to receive above-median or below-median amounts of precipitation.

The 90-day temperature outlook has three categories: above normal, below normal, and indeterminate, the latter meaning in effect: no forecast; or that the temperature could go with equal likelihood either way.

The 45-year old Gilman, who looks scarcely 30, seems tailormade for his present occupation as chief long-range forecaster for the National Weather Service. Born October 15, 1931, in Hartford, Connecticut, he grew up in nearby Storrs, where the University of Connecticut is located; graduated from a high school nearby and went thence to Harvard, where he earned a bachelor of science degree in physics in 1952, graduating with honors. Next stop was the Massachusetts Institute of Technology, where, in 1954, he received a master's degree in meteorology, and his doctorate in 1957. Doctoral thesis: "Emperical Orthogonal Function Applied to 30-day Forecasting."

"That's how I got this job," he said. In between times, for one year, Gilman worked on the research staff at M.I.T., and also taught a course in descriptive meteorology. "I taught only one term," he said, " and learned from that experience I wasn't cut out to be a teacher."

Next, Gilman, joined the then-named Extended Forecast Section of the Weather Bureau, under Jerome Namias, in September of 1958, and after Namias retired, became Chief of the Long Range Prediction Group in 1972.

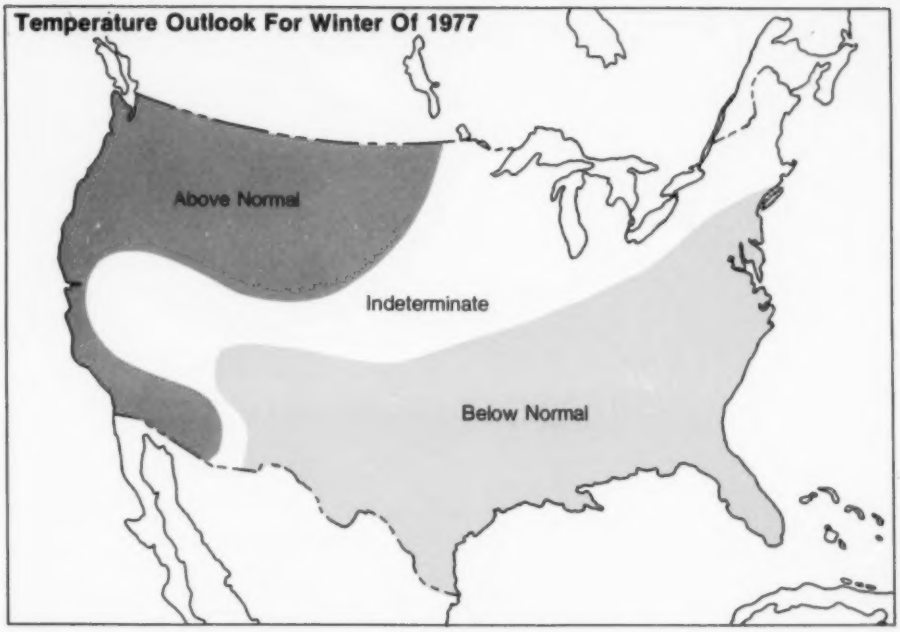
Gilman says the group is still using many of Namias's techniques, "but with some variations and simplifications."

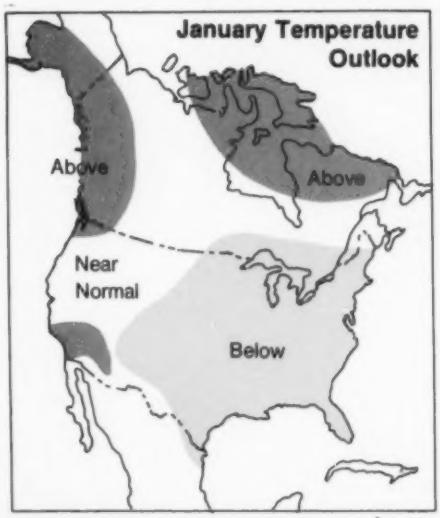
The group's success in predicting such abnormalities as the cold winter of 1976–77 has prompted many weather students to inquire just how Gilman's unit performs its wonders.

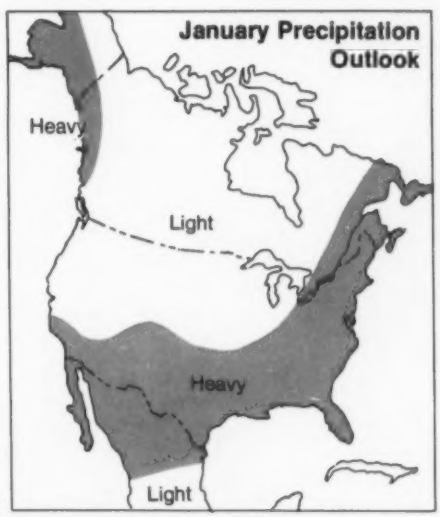
Gilman explains, "our principal working level in the atmosphere from which we derive our forecasts is the 700-millibar level of atmospheric pressure, or about 10,000 feet above the mean sea level pressure of 1013.25 millibars. In each of our monthly outlooks, we carry a map showing the expected configuration of this 700-millibar circulation because it is basic to what we expect on the Earth's surface. The 700-millibar level is high enough to pick up the basic character of the upper-level wind pattern, although it is not the level of maximum winds. That level runs between 35,000 and 40,000 feet, or 300 to 200 millibars of atmospheric pressure."

Above the surface friction layer in the atmosphere winds tend to follow lines of equal pressure, so that upper-air pressure patterns are roughly equivalent to wind patterns of the high-level steering currents so important to basic changes in the weather. Gilman continues: "The most important reason we chose the 700-millibar altitude is that we need to stay close enough to the ground to make good inferences about surface weather conditions, and that problem gets quite difficult when you get much above 700-millibars."

He says the maps he showed so frequently on network television this past winter—illustrating prevailing wind patterns causing our record-cold January—were based on the 700-millibar wind currents. In these maps, viewers saw the jet stream sweeping northeastward from the eastern Pacific to Alaska, then swooping sharply downward east of the Rockies to penetrate deep into southern U.S. Result: record warmth in Anchorage; record cold in Miami.







Winter temperature outlook issued by Long Range Prediction Group in late November correctly forecast below-normal temperatures over much of eastern United States and above-normal temperatures over the Northwest. Outlook for January also was generally good, with continued cold predicted for states east of the Rockies and above-normal snow and rain over eastern and southern states. (Maps slightly modified for NOAA Magazine.)

Gilman says another reason for using the 700-millibar chart is that it is a compromise level, with a long historical record going back comprehensively to 1948, and, in limited areas, to the late 1930's.

"You can't get good records for anything higher than that if you go back further," he says.

Gilman explains that his group keeps track of the behavior of the upper-level wind patterns on several different time scales, the longest of which is a 90-day scale. Next comes the monthly scale, then a 15-day scale, and lastly a five-day scale.

"We keep track of these on a continuous basis, in the sense that each successive five-day chunk gets a map posted for it right away, so that not all of our data-processing gets done just before the forecast day. If we didn't do this, we could be misled as to the true continuity of what's going on, because there are variations from one five-day period to another that may average out in the long run, and yet, individually be very helpful in diagnosing reality."

When it gets down to the nitty-gritty of how the group forecasts what's going to happen on the ground, Gilman explains that the forecast is done on two successive days.

"The first day we forecast what the 700-millibar flow will be—that is, how will it deviate from a normal pattern. That's the hardest part of the forecast. To predict this upper-level flow, we have several inputs. One is an examination of the sequence of development of atmospheric changes and then some cautious extrapolations of that sequence, including movements and rates of intensification of certain features, swelling of ridges, deepening or flattening of atmospheric troughs, and so on.

"A second element we use is 'persistence,' which is a little different from continuity. Continuity involves continuation of recent rates of change, persistence means to what extent some pattern that is present now will remain present. For that we have special statistics. These are calculated freshly every month for the forecast. They tell us, based on the behavior of the upper atmosphere during the past 30 years, which of the abnormal features at 700 millibars are the ones most likely to persist for the coming month or season, and, equally important, which ones are not, or are likely to reverse. This persistence part of our technique is objective—that is based on statistical formulas.

"We get what are called regression estimates, from autocorrelation coefficients, and apply them.

"The next thing we do is to see whether the clues from these two methods—the continuity or extrapolation method, which is rather subjective, based on recent trends, and the persistence or objective method— are mutually consistent in a statistical sense. The question is answered by applying 'teleconnection' statistics which evaluate the mutual likelihood of the various clues based on several years of atmospheric statistics.

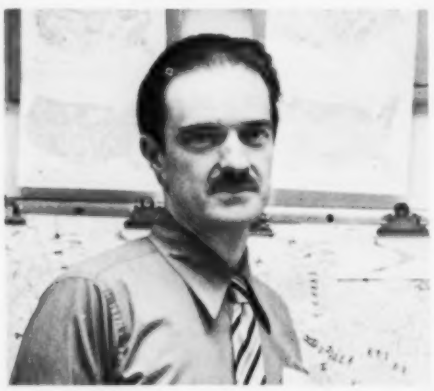
"If some of them are not consistent, that's a problem we must resolve before we can come up with a forecast. We need to make some kind of adjustment or throw out certain indications because we need a forecast pattern that is internally consistent in order for us to have a chance of being right."

Illustrating further the complexity of their thinking, Gilman says: "There are sometimes physical aruguments that we use also, to estimate major changes in the circulation. If, for instance, the strength of the westerlies around the Northern Hemisphere as a whole has been falling, we may need to look for a change in the number of waves in the westerlies. Or, if the pattern is setting up for a strong northerly flow from the Arctic over the North Pacific, that pattern can lead to a sudden and major readjustment of the whole wave pattern downstream over North America, and change our weather entirely in a matter of days.

"The second day, we make final revisions on the forecast for upper-air flow, and then make interpretations of this high-level pattern to determine weather features that will occur on the surface. To produce interpretations of temperature and precipitation, we use several methods.

"One method is to check back through our file charts for the last 30 years for the same time of the year as the period in the outlook

Robert Dickson is Deputy Chief and principal forecaster of Long Range Prediction Group.



Meteorologist A. James Wagner is assisting forecaster; also makes historical studies.

Meteorologist Robert Taubensee is the group's data specialist and verifier. Meteorological Technician Michael Gaidurgis, below, handles communications, keeps incoming data current.

Mathematician David Durdall does computer programming for long-range forecasts. Joanna Dionne also does programming; handles a wide variety of other assignments.

Photos: Edwin P. Weigel

to find cases in which the upper-level circulation resembles the one we are predicting. This is an analog technique. It is useful, but never completely satisfactory by itself. With this technique we assume that if we find an upper air pattern that closely resembles the one at hand, then we can forecast surface weather by analogy. It's not a matter of searching a computer's memory. It's merely a matter of consulting special flip-charts that we maintain of patterns over the past 30 years. It doesn't take long at all to go through this process. A trained eye can do it quite quickly. Bob Dickson is very good at it.

"Next, we have a set of objective equations that we bring in. These were derived primarily for use in five-day forecasts, and were developed some years ago by Dr. William H. Klein, now Director of the Weather Service's Systems Development Office. Dr. Klein adapted these for use in the 30-day outlook and used the 700-millibar height as his input. His equations give us a temperature estimate, not a precipitation estimate. We compare the results with the analog procedure described earlier, to see what kind of agreement we get.

"In addition, we have a set of conditional probability charts, devised primarily for five-day forecasting by James O'Connor, now Acting Chief of the Forecast Division of the National Meteorological Center. O'Connor's probabilities for both temperature and precipitation are very useful. They allow us to pick a key abnormality in the upper air at any particular location in the Northern Hemisphere which we feel strongly is going to be a major center of activity, and then determine the probabilities of various classes of temperature and precipitation that will result from that abnormality at the U.S. weather stations on our charts. The conditional probabilities allow us essentially to tailor our inferences to parts of the upper-level forecast we feel most confident about.

"And then there are a few more tools that operate directly from observed temperature patterns. We have probability tables for each of the 'lower 48' states based on years 1900 to 1960 which tell us what the chance is for a particular state being warmer or cooler than normal, depending on the weather it has had during the previous months. These are called contingency tables. We also have similar tables for a 10-year sample based on the joint consideration of the five-day forecast and the previous month's temperatures.

"All of these things are put together, and from our conclusions we draw maps."

One of the seeming peculiarities about the 30-day outlook is that the precipitation outlooks show no areas for "near median" precipitation, but, rather, divide sharply between "below median" or "above median" rainfall or snowfall.

For the mathematically inclined, Gilman explains that, "instead of referring a given outlook to the 'average' or 'normal' precipitation, we talk about a 'median' amount. A median is the dividing line between an equal number of wetter or dryer cases for a given location and month. Mathematically, the chance of getting the exact median is zero, because it is simply a dividing line between where there is a 50 percent chance of more-than-median precipitation and a 50 percent chance of less.

"Being right on the median is like being poised on the edge of a razor," he says, "but a median is a much simpler quantity to work with than a normal, and is more meaningful in our work."

"An alternate way of saying whether something is above or below the median" he explains, "is that the median is the 50th percentile point in precipitation amounts experienced by a given station over a 30-year period during the month in question."

How accurate have their forecasts been during recent months and seasons?

Gilman says 1976 was "a very good year" for his group. "While we claim a 60 percent skill for temperature over the long run, in 1976 and 1977 our skill has typically been more like 70 percent, and in some forecasts as high as 85 percent. These percentages refer to whether a temperature anomaly—that is, colder or warmer than normal by any amount at all—verifies in a network of about 100 stations.

"Our accuracy for precipitation is not so high, and has been running about the same as our long-term record. Here we usually claim only about a 55 percent skill above what one can obtain by applying climatology, or so-called "normal" precipitation for a given month."

The outlook for which Gilman and his group gained the most praise this year was their winter-temperature outlook issued in late November, indicating a colder-than-normal winter for much of the U.S. east of the Rockies, which took place with a vengeance, especially in January.

Gilman explains that the 90-day seasonal outlook is produced slightly differently than the 30-day outlook, since the continuity from one season to another cannot be followed in the same way continuity is followed from one week to another or one month to another.

"Changes seasonally overpower that kind of continuity," he says, "so we must be more statistical and less synoptic or chart based."

"Here we have persistence statistics not simply from one season to the next, but from one month, one season, two seasons, three seasons, four seasons and even eight seasons to the next. Thus, for a winter outlook, we are looking at statistics that will carry over the effects from the immediately preceding November, autumn, summer, spring and winter, and two winters back. We pick up a few statistics from each of these.

"There is no single complicated equation into which all of these calculations are dropped. When we put them all together, the result is in our heads. We post the charts separately so we can look at the clues from each of these different time periods and check them against one another for consistency by means of 'teleconnection' statistics. They have to agree, or an area falls into category "I" for indeterminate."

Who uses the long-range forecasts?

Gilman says his unit has about 2,000 regular customers, and that as best they can tell from examining the list, the breakdown is as follows:

Federal, state and local governments	about 25%
Agribusiness	about 10%
Fuel-energy organizations	about 10%
Media (newspapers, magazines, radio and TV networks etc.	about 10%
General commercial firms (not energy or agriculture)	about 20%
Heavy industry	about 10%
Private individuals	about 15%

"We have had a tremendous surge of interest in our forecasts since this year's cold autumn and winter," he adds.

Gilman says the seasonal forecasts in recent years have been very satisfying, with the ones for this autumn and winter registering above 80 percent in accuracy, based on measurements at more than 100 U.S. weather stations where colder-than-normal or warmer-than-normal temperatures were forecast. This compares with a long-term accuracy of about 60 percent for temperature, he says. The 1976–77 winter forecast—colder than normal east of the Rockies—was the seventh consecutive 90-day outlook that was better than a forecast based on climatological averages.

Plans for the future?

"We're very much involved in NOAA's proposed new climate program. This proposal is for a Climate Diagnostic Center, to which we would contribute. This would involve examination, on a regular basis, current climatic fluctuations on a monthly, seasonal, and annual time scale. The Diagnostic Center would be involved with short-term climate fluctuations—as compared with glacial or millenial fluctuations—and with human impact on climate. It is intended to be a complementary or coordinate activity to NOAA's Center for Climatic and Environmental Assessment (CCEA). Our unit would concentrate on predicting weather changes expected on a monthly, seasonal and yearly scale, and CCEA would concentrate on the impact of those changes.

"I think it will become more and more important for weather forecasters to predict changes six to nine months ahead because so many key Government decisions need that kind of lead time. We don't know whether we will be able to predict weather that far ahead or not. That will be one of our main efforts: to see if indeed it can be done."

Like many other weather men who think in long-range terms, Gilman is convinced that the U.S. has experienced a particularly benevolent weather regime in the central United States—the nation's breadbasket—from the period of the late 1950's to the beginning of the 1970's. He says this was a period without any real extremes of weather, particularly drought, and adds that "a lot of people got the idea we were on 'easy street' because they thought agricultural tenchology had overcome weather-related problems." He says it wasn't until recently that it was realized this period of favorable weather had created an erroneous impression.

Now, he points out, in recent years and months, Nature has shown us just how harsh she can be, and what we should plan for to escape calamitous shortages of food and fiber. □

Photos: Edwin P. Weigel

Photo: National Air and Space Museum

New light on an old mystery

What Happened to Amelia Earhart?

By J. GORDON VAETH

WAS AMELIA EARHART on a spy mission when she and her navigator, Fred Noonan, took off from Lae, New Guinea, for Howland Island on July 2, 1937? Did their flight plan secretly call for her to deviate from her announced course in order to overfly and observe Japanese fortifications on Saipan or Truk? Had she been asked by the Navy, or even by President Roosevelt, to reconnoiter the Marianas and Carolines?

These questions—and many like them—have been asked ever since Lockheed Electra, NR16020, stripped of every pound of excess weight and carrying every drop of fuel possible, lifted off from the runway at Lae. Earhart and Noonan were on the final stages of a world flight that had taken them from California to South America, across the Atlantic to Africa, then on to India, Southeast Asia, Australia, and, finally, New Guinea. Howland, their next stop, lay 2,550 miles to the north and east. After that would come Honolulu and then California again.

As the world knows, the Electra 10E never reached Howland. To help the flyers find it—the oval-shaped island is only 2 miles long, one-half mile wide, and 20 feet high—the Coast Guard cutter Itasca was standing by there and would serve as a communications center. The hours spent by those aboard that ship during the long night of July 1–2 (Lae was on the other side of the International Date Line) were never to be forgotten. Neither would be the confusion that reigned, the failure of Earhart to acknowledge messages or transmit when expected to, and the frustration of being unable to get a directional bearing on her too-few and too-brief voice transmissions. Her silence plus the fact that until late in the flight she wanted to take bearings on the Itasca rather than the Itasca taking bearings on her was puzzling to some. Although the reason may simply have been inadequacies of her radio equipment—she had left her CW key and trailing antenna behind in Miami to save weight—it contributed to the post-flight speculation that early on in the flight she might have been where she wasn't supposed to be. Also that she might have been approaching Howland from an unexpected direction.

Such speculation persisted and reached its peak in 1943 when Hollywood released "Flight for Freedom." Rosalind Russell played Tonie Carter an American woman flyer who agrees to get "lost" on an island in the Pacific to give the U.S. Navy an excuse to search for her in Japanese waters. Her companion on the flight, Randy Britton, was portrayed by Fred MacMurray. Although Tonie Carter and Randy Britton were depicted as fictional characters, the film left no doubt that they were supposed to be Amelia Earhart and Fred Noonan.

This movie, appearing when it did at the height of the war, shown to servicemen everywhere, and promoted as a "now it can be told," was probably more responsible than anything else for the stories and rumors that circulated during and after the battles in the Pacific about Earhart, Noonan, their "mis-

From 1963 to 1966 the author, now Director of System Engineering at the National Environmental Satellite Service, investigated in depth the circumstances surrounding the last flight of one of the most famous women who ever lived. His observations and conclusions are published in this issue, partly because they are the product of research by a NOAA member and partly because this month marks the 40th anniversary of Amelia Earhart's disappearance.

Amelia Earhart Putnam in a buoyant pose with her Lockheed Electra (opp. page), the "flying laboratory" in which she disappeared in 1937, and an earlier triumphal ticker-tape parade up lower Broadway in June, 1932, honoring her as the first woman to make a solo flight across the Atlantic (right).

Photo: National Air and Space Museum

Photo: National Air and Space Museum

In July, 1932, a dispirited Amelia Earhart Putnam talks to newsmen at Newark airport after being forced down in Columbus, Ohio, in unsuccessful try at new transcontinental flight record.

sion," and their fate. That Earhart might be found on Saipan was the subject of nervous pre-combat banter by the men in the landing craft approaching its beaches. Whether Earhart and Noonan had flown aerial reconnaissance over Truk was reportedly a subject of wardroom conversation by carrier-based pilots en route to attack it in 1944.

In the early 1960s, new information began coming to light, leading to a new line of speculation . . .

From Saipan, in the Marianas, came stories of a white woman and white man, said to have been flyers and spies, held captive by the Japanese before the war. One eyewitness even pinpointed the year of their arrival as 1937. The woman was thin, had short hair, and was wearing men's clothing. Supposedly she had died of dysentery in Garapan, Saipan's chief town. The man was presumed executed . . .

From the wreckage of an aircraft lying on the bottom in Saipan waters, a Bendix-type generator had been salvaged that perhaps had been aboard the Electra . . .

And from a gravesite, also on Saipan, remains, possibly Earhart's and Noonan's, had been flown to the United States for identification.

This new information was heady stuff for anyone interested in mysteries or aviation. It was particularly so for me, perhaps in part because I once had some slight personal contact with Amelia Earhart. I had corresponded with that gracious lady when she was at the peak of her aeronautical career and I was a teenager fascinated by everyone and everything that flew.

Most of this post-war information had come to light through the extraordinary efforts, energy, and persistence of Frederick A. Goerner, then of radio station KCBS in San Francisco. Intrigued by what he had found out, I arranged an evening meeting in Washington with him. I left it infected with his enthusiasm and believing that Earhart and Noonan might very well have been flying a spy mission, might have fallen into the hands of the Japanese, and might have died on Saipan.

I decided to make my own investigation, working from a vantage point within the weather service rather than, as Goerner had been doing, from outside. My motivation was simple: I believed that if Earhart and Noonan had given their lives for their country, the nation owed it to them to recognize and honor their martyrdom. Because I was unable to find anyone in government vigorously pursuing the subject—after all, 1937 was a long time before—I undertook to search for the answers myself.

Photo: U.S. Air Force

Amelia Earhart with Florence Klingensmith, winner of the Amelia Earhart Trophy Race.

Little could I foresee what the inquiry would involve. Against a background of Japan's fortifying and closing her mandated islands, the U.S. Navy's hunger for intelligence information about those areas, the international competition for commercial air routes across the Pacific, and the tales of the Electra having been possibly equipped with cameras and unannounced higher performance engines (even swapped for another plane), it was a formidable task to sort fact from speculation. Later, when I got into the subject of whether Amelia and Fred had been on Saipan, the search took some bizarre turns. Before it was over, it would even include the finding on the bottom of a frying pan the name and location of a supposedly key figure in the story—a figure, as it turned out, who wasn't so key after all.

The search for information led me to a variety of possible sources . . . several members of the wartime Office of Strategic Services . . . one Presidential candidate (Thomas E. Dewey) . . . three Marine Corps commandants (two of whom I talked with personally about Saipan) . . . one Vice President of the United States (Wallace) . . . one Secretary of State (Byrnes) . . . four members of Franklin Roosevelt's cabinet . . . one Fleet Admiral (Nimitz) . . . Muriel Morrissey (Amelia Earhart's sister) . . . Noonan's supervisor while with Pan American Airways . . . curators of libraries or document collections specializing in Far Eastern subjects . . . and, I suppose, dozens of persons in government offices, including the Departments of Interior, Army, Navy, Treasury, and Commerce.

There were others . . . aviation people like Eugene Vidal, one-time head of the Bureau of Air Commerce, who knew Amelia Earhart well and told me that President Roosevelt liked to call her "Little Lady" . . . a retired Brigadier General of the U.S. Air Force who inquired for me whether any Earhart or Noonan remains were housed in the collections of the Armed Forces Institute of Pathology . . . the representative of the U.S. Army's Quartermaster Corps who gave assurances that the missing pair were not buried in any national cemetery (she had been on the lookout for that possibility herself for some years) . . . the official of the Veterans Administration who checked to see if benefits had been paid in the name of Earhart (an unsubstantiated report had it that she was commissioned a major in the Army Air Corps before her flight) . . . and many more, including Rosalind Russell, the Tonie Carter of "Flight for Freedom."

At no time did it appear that anyone was trying to be evasive or attempting to hide behind the screen of "national security" or classified information. In fact I don't remember discussing any classified matter at all.

Photo: National Air and Space Museum

Crew of the $80,000 "flying laboratory" Lockheed Electra in March, 1937, posing in Oakland, California, before taking off for Honolulu on first attempt at round-the-world flight. Left to right, Paul Mantz, Amelia Earhart, Capt. Harry Manning, and Fred Noonan, who disappeared with her four months later on last leg of second attempt.

Allegations that the government is concealing "the real facts" about Earhart and Noonan are without foundation in my experience and opinion. What was surprising was that so many people were not only willing to help but apparently *wanted* to do so if they had anything to offer. Except for no more than perhaps a half-dozen, all of those contacted replied to my written or telephoned requests for information.

I, therefore, concluded that there is no cover-up being attempted of any of the facts concerning Earhart and Noonan.

I also concluded that they were not on any kind of a spy mission for the government.

President Roosevelt would almost certainly have known of such an assignment. If he did, none of his friends or colleagues whom I was able to locate had any recollection of his ever having said anything to that effect. It is a recorded fact that he assisted in getting the Navy to agree to refuel Earhart in flight over the Pacific (when she was interested in doing that) and later in arranging for the airstrips to be built to receive her at Howland (after she had changed her mind). The President's role in her flight does not seem to have gone much beyond that however.

According to Elizabeth J. Drewry, in 1964 Director of the Franklin D. Roosevelt Library: ". . . There is no evidence in the papers in this Library to substantiate the stories that President Roosevelt planned any part of the around-the-world flight of Amelia Earhart, sent her on any sort of 'mission,' or planned the attempts to find her . . . There is evidence of President Roosevelt's interest in the search for Amelia Earhart but there is no record of any action taken by him."

Henry Morgenthau, Jr., Secretary of the Treasury, reportedly shared Roosevelt's increasing concern over the Japanese military buildup in the Pacific. The Coast Guard was a part of his Department and it was a Coast Guard cutter that had been sent to Howland to home the Electra in. If there was a secret aspect to the flight, Morgenthau could well have known. He advised me that he had no information about any such mission.

From a veteran airman and friend, I gained the following perspective:

". . . I attempted to dissuade her from the flight from its very inception. But she was adamant. Her argument to me was that as a result of the flight she could achieve financial independence."

"At no time did any other consideration enter the discussion of the flight. My objection to the flight was purely on the basis that the equipment and ground support were inadequate to guarantee success. The mid-Pacific target made the calculated risk a sheer gamble, in my judgment.

"Amelia was a stubborn girl. Her very stubbornness was a part of her genius. I often kidded her about it. When she was so adamant about making the trip, I attributed it to that familiar stubbornness. It never occurred to me that the trip might have any other purpose than the one she stated."

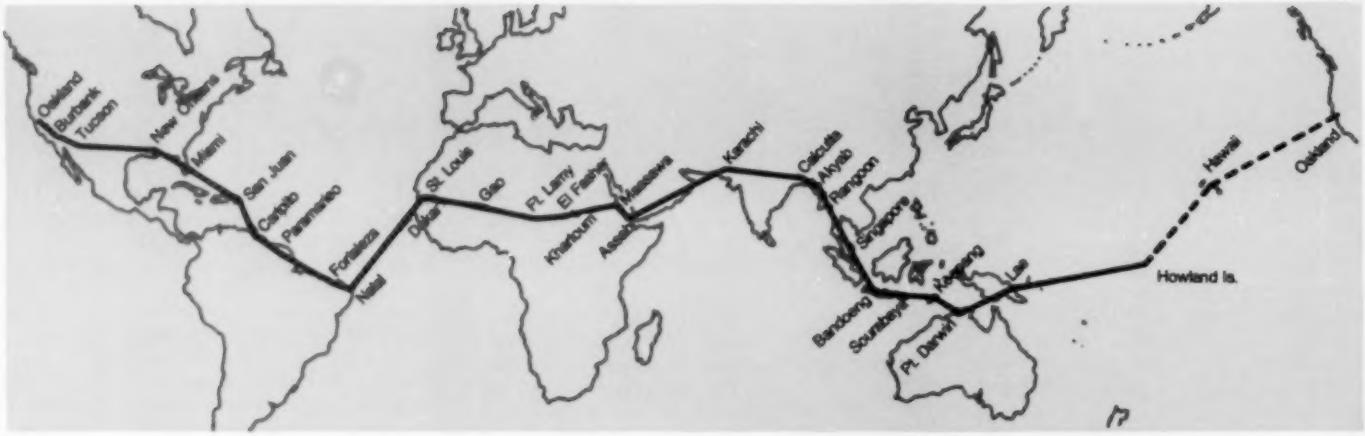
The real clinchers, however, that there was no secret mission came from two names apparently overlooked by other investigators into the Earhart-Noonan puzzle. Harry Manning was one. Charles Edison was the other.

Poorly remembered is the fact that Amelia Earhart—who would be in her late 70s today incidentally—made not one, but two, attempts to fly around the earth at the equator. Both took place in 1937. Both involved her Lockheed Electra.

Her first attempt was in a westbound direction originating at Oakland and crossing the Pacific via stops at Honolulu and Howland.

Photo: National Archives

Earlier ill-fated attempt at round-the-world flight ended in March, 1937, as Amelia Earhart's Lockheed Electra crashed on take-off from Luke Field, Honolulu. Photo at left shows plane just after crash, with navigator Capt. Harry Manning (in white shirt) climbing from wrecked plane. Later disassembly and repair work shown below.



Route of last flight, starting May 20, 1939, in Oakland, California, and proceeding around the globe through July 2, when Amelia Earhart Putnam and Fred Noonan took off from Lae and disappeared somewhere in the Pacific on the way to Howland Island. Below, the Coast Guard Cutter Itasca joined in the unsuccessful search for the intrepid aviatrix and her navigator.

She was to take along two expert navigators: Frederick J. Noonan and Captain Harry Manning. Noonan would leave the flight at Howland and return on the Coast Guard cutter that would be there. Manning, on leave from the United States Lines, would navigate the Howland-to-New Guinea leg, the leg on which any secret reconnaissance of Japanese fortifications would have taken place.

But the westbound crossing of the Pacific was not to be. The run from Oakland to Honolulu went beautifully. On takeoff for Howland, however, on March 20, 1937, the silvery twin-engined plane ground looped, severely damaging its undercarriage and a wing.

Immediately Earhart and her husband since 1931, George Palmer Putnam, arranged for shipment of the Electra to Lockheed for repair. In May she was ready to go again this time west-to-east. This time with only one navigator, Noonan. Manning had had to return to his ship.

Only two months had elapsed between Earhart's unsuccessful takeoff for Howland from Honolulu and the start of her second world flight. If she was intending to scout the Japanese mandates on her eastbound trip, it is logical to assume she had been also planning to do so on the earlier westbound. What better person to ask about her intentions in that respect than the man who was to have navigated her over that particular part of the route?

I located Harry Manning, retired and living at the New York Athletic Club. In a brief handwritten note, he said: "I am positive there was no government influence or mission of any sort . . . she, or rather we, had no official or unofficial spying mission in mind."

Charles Edison was another man who should have known, particularly if she had been on a mission inspired or arranged by the Navy. The son of the famous inventor, he was Assistant Secretary of the Navy at the time of the flight and later became Secretary.

According to Edison: "One thing I can say is that I am satisfied Amelia Earhart was not flying on any Navy mission. The matter was thoroughly discussed at the time and no one with whom I talked in the Navy mentioned any mission that she might have been on. The Island of Truk was being fortified by the Japanese in violation of treaties and the Navy

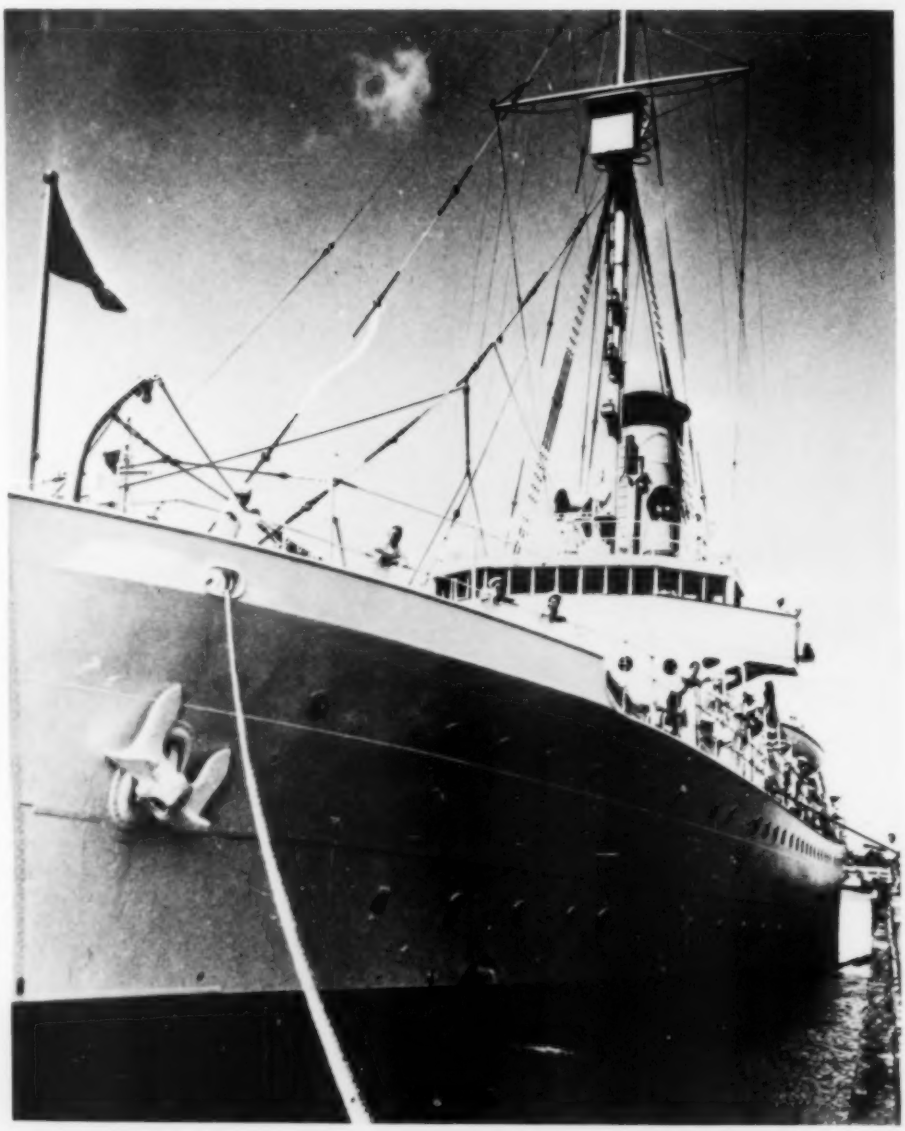


Photo: U.S. Coast Guard, National Archives

was very much interested, of course, in finding out more about Japanese operations in the surrounding islands, but we were always careful not to cause any incident. I feel certain that Amelia Earhart's flight was for some purpose of her own."

To my mind, Harry Manning and Charles Edison, both now deceased, provided enough information to decide once and for all the question of secret flight or no secret flight. Furthermore, if it had been the former, why did not George Palmer Putnam, who managed his wife's business affairs and flight arrangements, come out sometime before his death (about 1950) and say so? He, too, would certainly have known. But, as far as I could learn, this publicity-conscious and promotionally-minded man never did so. He is said to have spent considerable time and money trying to learn his wife's fate. This included visiting Saipan.

Saipan, again and again the trail seems to lead to that hilly island, 14 miles long and 2 to 5 miles wide in the Marianas. Were Earhart and Noonan ever on it? Did they die as prisoners there?

I was never able to get satisfactory answers to those questions, even though Fred Goerner helpfully kept me informed of developments concerning them. (He made at least four trips to the Central and Western Pacific to try to search them out.)

Lead after lead, clue after clue, seemed to fall apart. The aircraft generator was found to have metric-sized threads and bearings made in Japan. The remains that had been exhumed and flown to the States were identified as those of Saipanese natives. A picture or pictures of Earhart in the company of Japanese officers had allegedly been found on the island but no copy ever survived. What I though might prove the most tangible clue of all—a book in which the mysterious white woman prisoner on Saipan was supposed to have written something for a young girl—turned out to be a blind alley.

So it went, until, in my opinion, the only remaining viable clues were the eyewitness reports of persons seen resembling the missing pair. One of these accounts, the first, was apparently volunteered and not "suggested" as a result of anyone asking questions. How many others, I wondered—and still wonder—had been offered in anticipation of reward or to tell the questioner what the informant thought he wanted to hear?

The action, in this manner, was a half-a-world away from Washington. Most of what I learned of Saipan reached me secondhand at best. Not all of it however . . .

In 1964 the U.S. Naval Institute PROCEEDINGS published for me a request for information from U.S. Navy or Imperial Japanese Navy personnel concerning events that period of July 1–2, 1937. I received only one reply, but it was startling.

It put me in direct touch with a former Army technical sergeant who had been on Saipan following its capture. While there, a native woman had pointed out to him an unmarked grave where, so she gave him to understand, were buried a white man and woman who had come from out of the sky. His information had apparently been the basis on which the remains had been recovered that were sent to America.

I was fascinated by what he told me. Even more so, when he said he had seen the famous Electra in a hangar at the former Japanese airfield, Aslito, on Saipan. "You mean you actually saw the Earhart plane?" I asked him. He replied by telling me he could remember the first letters or digits of the registration number painted under the wing. He recalled, too, seeing the words Hamilton-Standard on the propeller blades. An incredible story, made all the more incredible when he added that he had later watched that same aircraft being doused with gasoline and burned.

To this day, I cannot reconcile his story with the other Saipan information I possess.

In 1966, Doubleday and Company published Fred Georner's "The Search for Amelia Earhart." In it he concludes that she had scouted Truk, missed Howland, and backtracked to try to pick up the British-owned Gilberts. He believes she did find land but that it turned out tragically to have been the Marshalls instead. After crashlanding there, she and Noonan were picked up by the Japanese and later removed to Saipan where they were held until they died. Goerner does not mention it in summarizing his findings but conceivably their plane could also have been transported to Saipan thereby accounting for the Army's sergeant's claim to have seen it there.

My own conclusion is that there is no hard evidence of any kind—to support a finding other than that the Electra simply ran out of gas and its pilot and navigator were lost at sea.

A weather analysis, prepared by a Navy meteorologist in Hawaii, showed severe weather and strong headwinds between Lae and Howland at the time of the flight. One of Earhart's few radio messages mentioned "overcast," meaning that Noonan may have been unable to take celestial fixes.

In the absence of positive evidence to the contrary, I now believe that the flight ended when the tanks of the Electra went dry and the 550 horses of each of its Wasp engines were stilled.

Yet there is the nagging question of those eyewitness reports . . . certainly not strong evidence . . . but strong enough to keep the door open to the possibility Earhart and Noonan were captured by the Japanese.

It was her friend Eugene Vidal, I believe, who told me, as Goerner suggests, that her plan was to retrace her flight path and try to find a landing place in the Gilberts if she couldn't locate Howland. If she did this and if she was north of her projected track, she would have ended up in the Marshalls. And that's why one particular report of her being seen there is of special significance.

This information came to light through a former U.S. Navy officer who was a member of the military government established in the Marshalls after American forces landed there in 1944. This officer, now a Washington, D.C., attorney, was told by a native, considered highly dependable, that before the war a plane had landed in the Marshalls and that a woman flyer, a white woman, had been picked up and taken away by the Japanese. This native said nothing about the woman having had anyone with her. He was repeating only what he had been told by a Japanese who was presumed dead by 1944. Thirdhand information this was, but potentially significant enough to keep alive the thought that NR 6020 might have come down in the Marshalls–and that its wreckage might even still be there today.

Time is running out. The trail of Amelia Earhart and Fred Noonan is growing cold. Additional information will become increasingly difficult to come by. Yet the quest will go on and on.

Amelia Earhart was more than America's most famous woman flyer. She was, in her day, the most famous woman in the world. The possibility of being the one to solve the mystery of her disappearance is tremendously appealing. Publication of these observations will, it is hoped, minimize future speculation and direct the efforts of tomorrow's investigators into the most promising areas. □

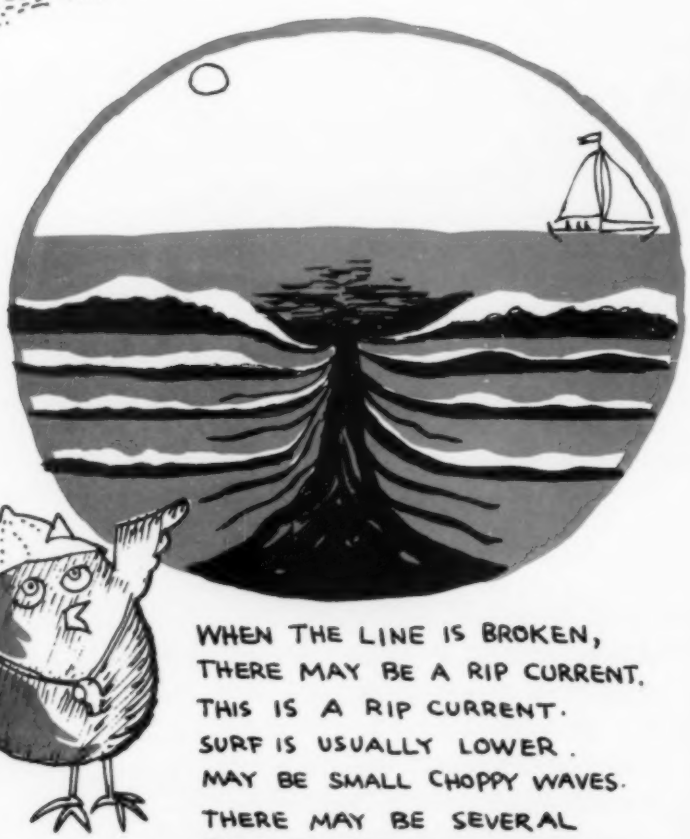
Photo National Archives

In memory of Amelia Earhart, a lighthouse was built on Howland Island, near the spot where she was believed to have disappeared. The Director of the Howland Territory, Ernest Gruening, lays the cornerstone in January, 1938.

OWLIE SKYWARN'S LIFE-SAVING TIPS ON RIP CURRENTS

WATER MOVING OUT FROM THE BEACH USUALLY 10-20 FEET WIDE - **BUT** WHEN WATER MOVES **ALONG** THE BEACH, A RIP CURRENT MIGHT DEVELOP!

USUALLY THE LINE OF BREAKERS IS EVEN.



WHEN THE LINE IS BROKEN, THERE MAY BE A RIP CURRENT. THIS IS A RIP CURRENT. SURF IS USUALLY LOWER. MAY BE SMALL CHOPPY WAVES. THERE MAY BE SEVERAL RIPS ON THE SAME BEACH. THEY MAY COME AND GO.

HOW YOU KNOW YOU'RE IN A RIP CURRENT...
WHEN FEET TOUCH BOTTOM OCCASIONALLY
YOU FEEL THAT THE BOTTOM IS MOVING
TOWARD SHORE.
YOU FIND YOU'RE FARTHER OUT THAN
YOU EXPECTED TO BE.
YOU ARE MOVING FASTER THAN
THE OTHER SWIMMERS.

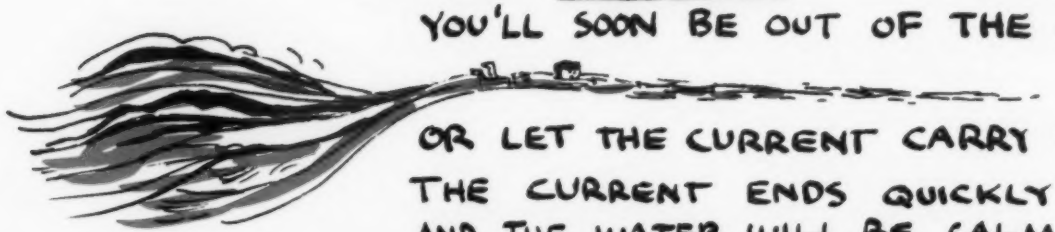
WHAT TO DO AND WHAT NOT TO DO

1. DON'T PANIC 2. RELAX!

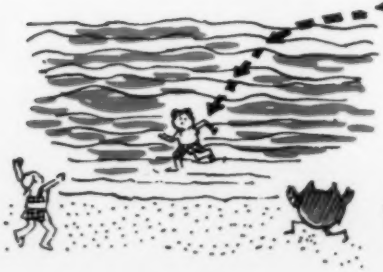
3. DON'T FIGHT THE CURRENT.
IT WILL TIRE YOU OUT.

4. DO NOT TRY TO SWIM
TOWARD THE SHORE.

5. SWIM PARALLEL TO THE SHORE
YOU'LL SOON BE OUT OF THE CURRENT..



OR LET THE CURRENT CARRY YOU OUT.
THE CURRENT ENDS QUICKLY
AND THE WATER WILL BE CALM.



6. SWIM SLOWLY PARALLEL TO THE SHORE;
THEN SWIM TOWARD THE BEACH.

NEVER SWIM ALONE!

TELL OTHER PEOPLE ABOUT RIP CURRENTS

Looking for trouble at

THE CLEANEST PLACE IN THE WORLD

By JOAN VANDIVER FRISCH

THE sun shone brightly on the stark landscape as William E. Cobb peered out the Hercules C–130 aircraft's small window. The NOAA scientist wanted to get a better view of his adopted "home-away-from-home"—9,000 miles from the more familiar surroundings of Boulder, Colorado.

Some changes has occurred since he last set foot in Antarctica—the coldest, highest, and windiest continent on earth. Gone were the clusters of makeshift wooden and metal huts, half submerged by blowing snow, which had housed scientists from around the world in years past. In their place was a 60-foot (20-meter) high geodesic dome and bright red skylab, completed two years ago, to replace the original structures which had finally succumbed to the relentless force of deepening snow and now lie buried 30 feet (10 meters) below the surface.

During the past summer season, a new building called the Clean Air Facility was constructed a few hundred meters upwind from the main camp. The structure was designed to house various air monitoring program instruments including atmospheric electricity sensors.

"Except for occasional bursts of aircraft exhaust during the short austral summer, the new facility provides the cleanest air monitoring site in the world," says Cobb, a meteorologist with the Environmental Research Laboratories' Atmospheric Physics and Chemistry Laboratory.

"We are here because the polar plateau provides an ideal environmental monitoring site. Absence of man-made aerosols, daily cycles, and radioactive soils are all desirable for long-term atmospheric electric measurements."

In fact, according to Cobb, there are few places left on this planet where the influence of mankind on the local atmosphere has not become a disturbing factor. For this reason he considers the South Pole the premier "clean air" site in the world.

"If measurements are made which indicate a significant change in conditions such as the level of suspended particulates in the environment of the South Pole, our ultimate clean air site, then there must be a real cause for concern for the impact of these floating particles on the global climate," Cobb says.

According to the NOAA scientist, it is well known that certain aspects of atmospheric electricity, especially conductivity, monitored at sites remote from sources of pollution or other local influences, can be interpreted as an index of the particulate burden of the atmosphere.

For this reason scientists with the Atmospheric Physics and Chemistry Laboratory have made atmospheric electric measurements at mountain tops in the continental United States, from Mauna Loa Observatory in Hawaii, and from NOAA research vessels in mid-ocean to obtain a reference standard or "atmospheric benchmark."

When the opportunity arose, it was logical to establish a similar data reference for the frigid South Pole. As a result the South Pole Atmospheric Electric Program, supported by NOAA and the National Science Foundation, was born and is now in its fourth year of a five-year project.

"We hope that the South Polar environment is representative of natural conditions which have existed there for centuries and not yet altered by mankind's activity on this planet," Cobb says. "By establishing the electrical state of the South Pole environment now, we can determine what changes may occur in the atmospheric electric climate in the future."

Besides benchmarking the atmosphere's electric climate on the polar plateau, the other

major objective of the South Pole Atmospheric Electricity Porgram is to investigate those processes which control and maintain the flow of electrical current between the earth and the ionosphere. (The ionosphere is an invisible atmospheric shell of electrically charged particles which envelops the earth from 50 to 650 miles above the planet.) Cobb and his colleague F. James Holitza, an APCL physicist, made the trip to Antarctica this past January to install new sensors near the Clean Air Facility for monitoring the electric field air-earth conduction current and the electrical conductivity of the atmosphere.

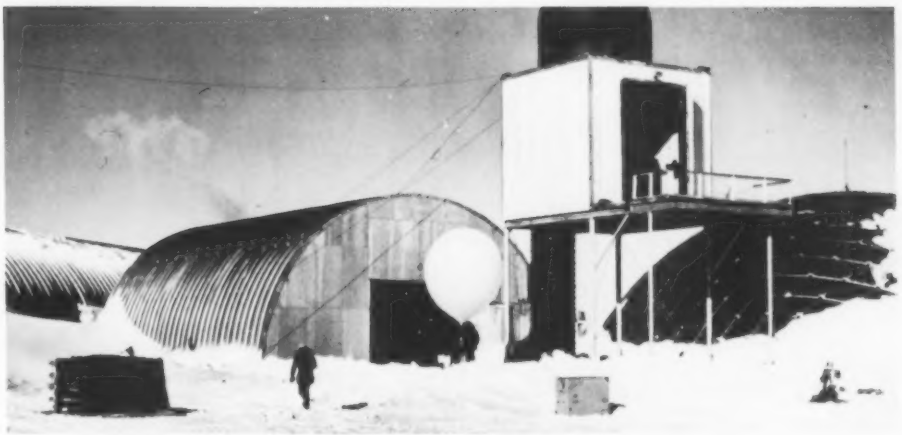
In addition to surface measurements, Cobb and Holitza made balloon observations of the air-earth current density with the similar objective of establishing an upper atmosphere benchmark. Working amid temperature highs of between minus 12 and minus 18 degrees Fahreheit, the NOAA scientists daily released radiosonde instruments with 325 foot (100 meter) long antennas and miniature electrometers, capable of detecting the small current continuously flowing to the earth. The balloons frequently rise to more than 20 miles (35 kilometers) above the earth, providing an air-earth current profile through the stratosphere. The current flow is sensitive to aerosol conditions since the electrical lines of force will halt when they come in contact with dust particles, ice crystals, and raindrops. Aerosol particles which are either transported to, or formed within, the stratosphere—the weatherless region of the atmosphere between five and 50 miles above the earth—have suspended lifetimes much longer than for particles in the troposphere, or lower atmosphere.

"It is important to document the existing state of the stratosphere as fully as possible now so that future changes may be detected, changes that might follow widespread use of the supersonic transport aircraft in future years," Cobb explains.

While the application of electrical measurements at the South Pole to aerosol pollution are a prime concern, Cobb and his co-workers are equally aware of the interesting results obtained concerning world-wide aspects of atmospheric electrification.

"The global concept of atmospheric electricity, according to the most widely accepted hypothesis, is that which views the earth and the ionosphere as highly conducting surfaces separated by an imperfectly insulating atmosphere," Cobb says. The first observations of atmospheric electricity, which helped lead to this hypothesis, were done by scientists in the 18th century. They concluded that the earth was negatively charged and that a positive current was continuously flowing to the earth in fair-weather areas. This belief raised what has become one of the most important problems of atmospheric electricity: How is this negative charge on the earth maintained?

The same hypothesis also concludes that a flow of positive current from the earth to the ionosphere exists where thunderstorms are occurring. Since there are 1,500 to 2,000 storms continually in motion somewhere around the globe, they act as a large generator which controls and maintains the "global electric circuit" and returns to the ionosphere the positive charge received by the earth in fair-weather areas.



Amundsen-Scott Station—Pole Station, as it is better known—atop the world's highest, coldest desert, houses NOAA clean air monitoring site, other scientific projects.

Confirmation of this hypothesis, according to Cobb, has always been difficult because the worldwide thunderstorm activity has never been adequately determined, and because global effects at most measuring sites are masked by local influences on electrical measurements.

"Fortunately these disturbing influences are not a problem at the South Pole, and the detection of global effects is made easier," Cobb says.

Results of the research conducted by Cobb and his colleagues indicate that surface measurements of both the electric field and the air-earth current density at the South Pole support the global thunderstorm theory. The mean value of the air-earth current will sometimes double from one day to the next. Since it is not likely that global thunderstorm activity could double from one day to the next, there must be additional factors which influence the global electric circuit.

Evidence is now emerging from the continuing data analysis to indicate a solar-terrestrial correlation in the South Pole measurements. Detection of direct sun-earth links is a possibility at the South Pole since particles carried by the solar wind are funneled to the lower regions of the atmosphere in polar areas.

"The influence of the solar wind upon the global circuit current or upon thunderstorms which are imbedded in the circuit is not known or understood," Cobb explains. "But the importance of investigating such interactions is obvious since a significant portion of the earth's rainfall is derived from thunderstorm precipitation."

Establishing an environmental benchmark of atmospheric conductivity now in order to detect changes in the global atmospheric electric climate in subsequent years has further applications. "For example," says Cobb, "there is at present considerable interest among atmospheric electricians as to what extent the release of krypton 85, a radioactive gaseous by-product of nuclear fission, will affect the electrical state of the free atmosphere over the next few decades."

Krypton is released to the atmosphere in a controlled manner from nuclear electrical generating plants and within the limits established by the Energy Research and Development Administration, and is not considered biologically hazardous to animal or plant life. But because of the projected increase in nuclear power stations and the characteristics of krypton 85, scientists have calculated that the ionization level in the atmosphere will be significantly increased during the next 50 years. Calculations based on the predicted release of krypton 85 indicate the increased ionization due to the readioactive element will decrease the columnar resistance between earth and the ionosphere by about 15 percent if the accumulation of krypton is allowed to reach one percent of the maximum permissible concentration now permitted by ERDA.

"If the predicted release of krypton 85 occurs, which will be distributed throughout the atmosphere in less than three years, then the possibility of the following chain of events should not be ignored," Cobb warns.

Krypton 85 will increase the small-ion concentration in the atmosphere, thus increasing the conductivity and reducing the columnar resistance between the earth and the ionosphere. The reduced columnar resistance will result in an increased global circuit current, the positive polarity current that flows to the earth in fair-weather regions, and returns to the ionosphere in thunderstorm regions. The increased electrical current flowing through thunderstorms may enhance the processes of charge separation and droplet coalescence and on a global scale, the product of thunderstorm precipitation.

"Our present knowledge is insufficient to predict whether or not changes in the radioactivity and the electrical structure of the atmosphere will result in climatic changes," Cobb explains. "It is generally agreed, however, that environmental radioactivity, atmospheric electricity, and inadevertent weather modification are not independent entities."

The application of the atmospheric electrical methods by Cobb and other scientists will help in investigating some of the physical processes occurring in the earth's atmospheric envelope, and problems which will surely face coming generations on this planet. □

In action over
the entire earth

Workhorse In Space

By ROBERT W. POPHAM

FOR about $300 and some spare-time labor, David Farmer and his sone George daily enjoy one of the greatest shows on earth—or rather, over the earth. They view the sweep of frontal systems and storms bearing down from the West, hurricanes on the East and Gulf Coasts, the Hudson Bay icepack, and the rest of the hour-by-hour drama that constitutes America's weather—all from the basement of their home in Niles, Illinois.

The Farmers are among the 800 or more persons—weather buffs and professionals alike—who receive pictures continuously from orbiting environmental satellites in space. The father and son built their set by modifying an old Western Union facsimile recorder they bought for $15, and adding a homebuilt receiver and antenna. Admittedly, their pictures aren't as sharp as those received on commercial gear (which sells at prices up to $45,000), but the Farmers are in it for fun.

For others, and for most APT users, it's serious business.

Gerry Kennedy had a more compelling reason for obtaining his first weather pictures from space. He was an electronics specialist on a British icebreaker in the Antarctic at the time. His ship was surrounded by ice. Communications were garbled. Information on weather and sea ice conditions were virtually non-existent. Without such information, it would be difficult to extricate the ship from the ice and avoid or prepare for storms which might be encountered enroute back to base in the Falkland Islands. Partly as a challenge, partly out of desperation, the skipper asked Kennedy if he could build a system "to copy pictures from one of those weather satellites orbiting overhead."

Kennedy accepted the challenge. He adapted a shipboard receiver and display device, and fashioned an antenna out of coaxial cable wrapped around a wooden keg. With this, he received four clear pictures of their operating area—sufficient to select a safe passage out of the ice and to ascertain that no major storms were headed their way, at least for the next several hours.

More pictures could have been received on subsequent orbits had not the antenna, which maintained its rigidity in the early morning sub-zero temperatures, "wilted" as the sun's rays struck it.

APT station assembled in Niles, Ill., home of David and George Farmer—a $300 investment that brings them continuous satellite photography, and hours of fun. (Opposite) George Farmer adjusts antenna of his APT receiver.

The direct readout imagery that Farmer and Kennedy acquired are part of the Automatic Picture Transmission (APT) services provided by polar orbiting spacecraft operated and managed by NOAA's National Environmental Satellite Service. A High Resolution Picture Transmission (HRPT) service and a Direct Sounder Broadcast (DSB) service also are provided by the current series of polar orbiting NOAA satellites, but require more sophisticated ground equipment than that needed to receive APT images. In addition, geostationary satellites—both "old" and new—provide broadcasts which can be and are acquired on relatively inexpensive ground equipment built and operated by US and overseas government agencies, commercial organizations, academic institutions, and even private citizens.

The most popular, most numerous, and most familiar of these is the APT service. It was initially provided by a TV camera and communications sub-system designed and built by NASA and RCA for testing aboard an experimental weather satellite, TIROS VIII, launched in December 1963. The Service was intended as a low-cost method of providing high speed, global dissemination of satellite imagery. Prior to this, the cloud information in pictures from earlier TIROS experimental satellites was extracted by scientists who drew cloud-depiction maps, ("nephanalyses") labeling cloud forms, features, and patterns according to a code devised specially for this purpose. Transmitted on already overcrowded surface facsimile networks, these nephanalyses frequently reached major U.S. forecast offices too late to be used in forecast preparations.

Several APT ground stations were established in 1963 throughout the United States and aboard the aircraft carrier USS Saratoga to receive and evaluate picture reception from TIROS VIII. Additionally, details of ground station construction were provided to interested foreign nations, a practice that continues today. Before TIROS VIII failed three years later, 13 APT stations in seven countries had copied real time satellite images via direct APT readout.

By the end of 1972, nearly 500 APT stations in 74 countries were receiving imagery from polar-orbiting satellites. At one time, the National Weather Service operated 11 stations in the contiguous United States, one on Kwajalein, and one aboard the Glomar Challenger, engaged in the Deep Sea Drilling

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Robert Popham is Coordinator of Satellite Direct Readout Services at the National Environmental Satellite Service.

Project. This shipboard unit is still being used to great advantage; the others have been deactivated because of improvements in the quality and quantity of satellite imagery, and of surface communications systems for disseminating them, within the U.S.

Although the number of NWS-operated APT stations has dwindled, both the Air Force and the Navy maintain many APT stations in the United States and abroad. Shipboard units have played a major role in preventing damage due to storms and in increasing the effectiveness of operating forces. For example, at least one aircraft carrier was able to avoid two major storms enroute back to the U.S. from southeast Asia in 1973. Neither had appeared on weather charts available to the ship's meteorologist. (In the late 1960's this same vessel encountered an unmapped storm which caused several hundred thousand dollars in damage and put the ship out of operation for several weeks.) Weathermen on another carrier, operating with NATO forces in the western Atlantic, were able to discern the limits of a huge fog bank that had virtually immobilized aircraft operations, and thus were able to direct the ship and support forces to a clearer operating area.

An NWS meteorologist aboard the Glomar Challenger, analysing imagery obtained from an on-board APT unit, advised the ship's captain of the approach of a storm which had not been indicated on facsimile weather charts received by the ship. A few hours later the storm struck with 60 miles per hour winds and high waves—but not before several thousand feet of drilling pipe, costing $43 per foot, had been recovered from the sea and stored on board.

Many other vessels, including NOAA's Oceanographer, the Coast Guard icebreaker Glacier, and a Royal Navy aircraft carrier have had, or still carry, APT units on board. Ships of other nations also are equipped with this valuable weather observation tool.

As varied and numerous as shipboard applications may be, examples of data acquired by land based systems far exceed this number, as, of course, do the number of land-based stations.

In Finland, for instance, an inventory of deciduous forest cover was undertaken using APT imagery, and results, when compared with aerial photo reconnaissance of the same areas, varied by only five percent from those obtained by aircraft. While the aerial survey required six years to accomplish, that done by satellite took only a single winter season with a few excellent, cloud-free images. Similarly, fishing and logging activities in French Guyana, where monsoon-type rains can quickly transform peaceful rivers into swollen torrents, have benefitted from APT imagery used by the nation's meteorological service in forecasting such storms. Major systems that produce heavy flooding can be readily observed in APT images.

Individuals cloud forms associated with lightning—cumulo-nimbus clouds (CB's)—cannot be identified in most APT pictures, but frontal systems, which often contain CB's, can. The forestry services of Canada and Australia use APT images to detect the

presence and forecast the movement of such systems, enabling them to direct aerial surveillance—a key weapon in forest fire suppression—to areas where the probability of lightning-started fires is greatest. And on tiny Tonga, where the entire copra crop was destroyed just prior to harvesting by an unpredicted Pacific storm, two Peace Corps volunteers were reported to be building a simple APT station to give early warning of such storms in the future.

Locust control efforts in northern Africa and the Middle East, weather modification activities in the Sahel drought zone, weather and oceanographic research oriented to the Peruvian anchovy and guano industries, land mapping in western Africa, and crop surveillance, bird migrations, and sea ice reconnaissance in Canada—these and many other activities have been greatly assisted by the APT service.

Perhaps the most publicized use of APT imagery involved a small Mexican city and a partially completed dam. Officials feared that a dam under construction near the city of Gomez Palacios would not be able to hold back an expected deluge, if rain from a storm system approaching Mexico from the Pacific were to fall in the watershed area behind the dam. A decision had to be made regarding possible evacuation of the nearly 100,000 people in the city and areas below the dam. Mexican meteorologists predicted—on the basis of APT pictures of the storm—that the storm system would weaken and take a more northerly course, and that the dam would hold the small amount of run-off expected upstream. Their predictions, fortunately, proved correct.

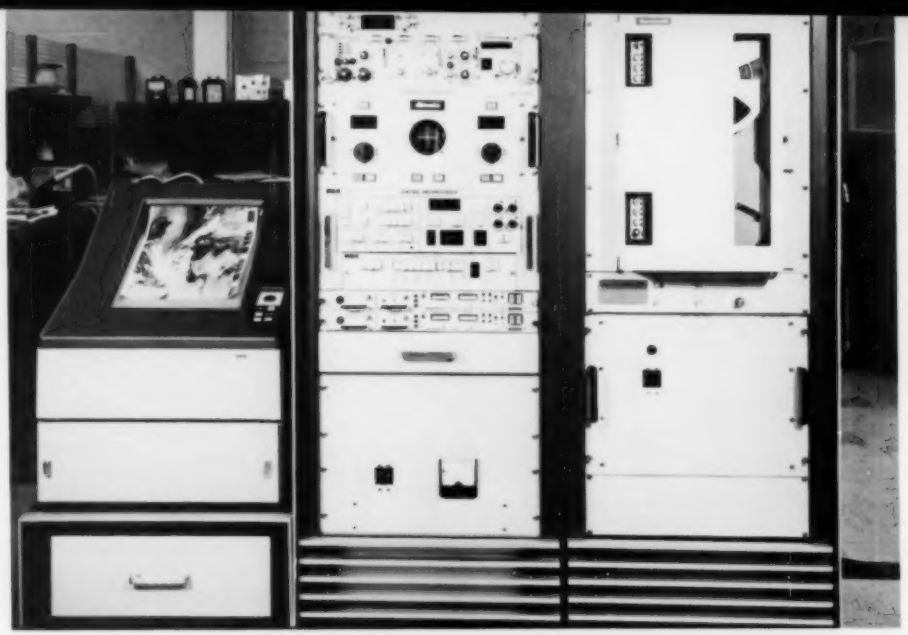
The World Meteorological Organization, recognizing the important role that a relatively simple, low cost APT station can play in the forecasting efforts of many nations, has encouraged each of its 133 member states and 12 trust territories to establish at least one direct readout APT station. Thus far, 123 countries and territories have established APT ground receiving terminals, with more than 350 known APT stations being operated by government, civilian, and military agencies.

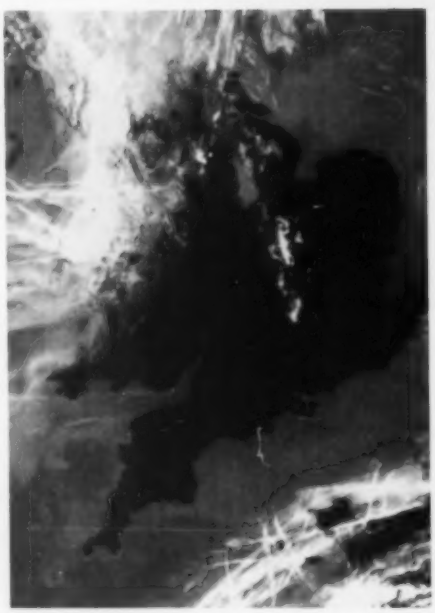
NESS maintains and operates the U.S. satellite system, of which the direct readout services are a significant part, and attempts to keep a station directory and mailing list of all APT stations. This enables NESS to inform station operators about developments that could affect them, such as new satellite launches, instrumentation changes, sub-systems failures, and product and schedule changes. Additionally, NESS helps scientists and others who may need to know if a satellite readout station or stations exists in a given area. During the recent Sahelian drought, the WMO, working closely with the United Nations, needed to know which APT stations might be able to help locate and track cloud forms conducive to artificial rainfall stimulation (cloud seeding) efforts. The names, locations, and operating agencies of all known stations were provided by NESS.

At least 95 academic institutions—high schools, colleges, universities, maritime and are actively engaged in some aspect of the satellite direct readout program. For members of some of these institutions, construction of an APT ground station means "hands-on" experience in building and operating a useful item of electronics hardware. In the University of New Hampshire Engineering Department, it goes further; a student project, which had as its purpose construction of equipment that could meet the objectives of the Sea Grant program, may help states assess, tap and manage their marine resources, and aid the development of new knowledge to advance the marine sciences and related technologies.

At Ambassador College in Great Britain, students built an APT station and provided images to TV stations, newspapers, other schools, commercial firms, and special Encyclopedia Britannica reports.

Radio "hams", scientific observations, TV stations, Explorer scout posts, a U.S. Civil Defense Unit, a Civil Air Patrol Unit, and a number of private electronics or weather firms constitute the 500 or so members of the known non-government community of APT enthusiasts. The Nuffield Radio Astronomy Laboratories (Jodrell Bank) in the United Kingdom and Griffith Observatory in Los Angeles, each maintain an APT station. Station KATU–TV in Portland, Ore., is one of several TV stations across the US that have received satellite imagery directly and broadcast it to viewers. A high school Science Fair exhibit won Conrad Baranowski a one-year





Equipment used to receive High Resolution Picture Transmission (HRPT) images (top). Not a home workshop project, this capability is now possessed by at least 11 nations, and more than 20 others are being planned. Image (below left) received by Scotland's Dundee University shows virtually cloud-free United Kingdom. Hurricane Belle image (below right) was received by Lou Follet of New Jersey.

scholarship to the Worcester Polytechnical Institute. Pictures of the March 1971 eclipse, hurricane Cleo and other storms, recorded on APT equipment housed in a converted tool shed in Aubrey Burton's Richmond, Va., back yard, have been seen on local TV and in area newspapers. An ophthalmologist in Pasadena, Calif., won't fly his private plane on long trips without a recently-acquired satellite photograph in the cockpit with him, and a professor of botany is the author of the most comprehensive, recent report on APT satellite ground construction.

At least 14 manufacturers—six in the United States—produce and market APT ground stations. Automatic tracking, image enhancement, and other ancillary features are available. Most government agencies have purchased their equipment from these manufacturers, but a few countries—Brazil, India, and Japan among them—construct their equipment locally. Popular articles appearing in Scientific American, 73 Magazine, QST, Electronics, and other publications in the United States, Canada, the Netherlands, and Italy provide much of the information a ham radio operator needs to build an APT station. The U.S. Government—and NESS in particular—supplies copies of, or references to, many of the documents needed to build any of several types of satellite readout stations.

Probably the most popular article of this type was "Weather Satellite Picture Receiving Stations—Inexpensive Construction of Automatic Picture Transmission Ground Equipment" (NASA SP-5079), published in 1968 and up-dated in 1969 (SP-5080) to reflect changes in the system needed to acquire images from a Scanning Radiometer, presently the primary APT instrument. C. H. Vermillion recently has produced a later report which describes in detail a digital scan device for improving image displays. His early reports were, and still remain, the most authoritative sources of instruction to novice designers and experienced electronics engineers alike on the subject of APT ground station construction and operations.

APT is not the only direct readout service provided by earth satellites and available to interested "customers". The current series of NOAA satellites also provide High Resolution Picture Transmission (HRPT) and Direct Sounder Broadcast (DSB) services, as will future polar-orbiting spacecraft. Acquisition and use of HRPT and DSB data require expensive, sophisticated ground hardware for signal reception and processing. At a cost of $200,000 to $300,000 per station, it is highly unlikely that any will be found in someone's basement.

HRPT services are of special interest. While the high resolution of these images (one kilometer) is somewhat poorer than that available elsewhere, the service is less subject to operational vagaries, and information for constructing an HRPT station is readily available from NESS. Landsat, operated by NASA for the Interior Department, has a much superior ground resolution (100 meters), but its nine-day revisit cycle does not lend itself well to operational activities requiring a more frequent observation schedule.

At least 11 countries now have the capability to receive HRPT imagery from the polar orbiting NOAA-5 satellite. India's Space Research Centre will have an operating HRPT station before mid-1977, and at least two others may be established by the Indian Meteorological Service before 1980 to support monsoon experiments. At least 25 other nations are either planning or procuring HRPT stations.

An HRPT station may play a significant, if not major, role in the economic development and political future of the Antarctic continent. The Food and Agricultural Organization considers krill—a shrimp-like crustacean that forms the principal food of many Antarctic animals—to be one of the largest sources of food supply for man. Additionally, natural gas has been discovered off Antarctica's coastline. These two resources may constitute only a small fraction of the potential wealth of this continent.

Antarctic exploration, transportation and even the survival of the explorers, will depend upon accurate observations and forecasts of meteorological and oceanographic phenomena. A major observation tool will be polar orbiting satellites capable of transmitting high resolution imagery to a local readout station on the continent. Steps to make this possible already have been taken by the National Science Foundation, which has allocated funds for a station to be established at McMurdo Sound by late 1978.

In 1887 the Norwegian explorer and scientist Fridtjof Nansen deliberately froze his vessel Fram in the Arctic icepack near Spitzbergen. After drifting for two and a half years across the top of the world, the Fram emerged from the ice near Greenland, bringing with it a wealth of Arctic meteorological and oceanographic data. In late 1977 this historic voyage may be duplicated when a decommissioned Navy icebreaker will be frozen in the Arctic pack at approximately the same point that the Fram began its "voyage". Scientists aboard this icebreaker, however, may have the assistance of an HRPT station to help them collect and report sea ice and weather conditions, and to provide support for aircraft resupply and personnel rotation flights.

HRPT images supplied by the French Meteorological Service in April and May 1976 were used by an FAO remote sensing team in Rome as an aid to predicting meteorological conditions conducive to the emergence and migration of desert locust swarms in northern Africa. Images received on ground equipment in Scotland and Canada were used to support exploratory oil drilling activities in the North Sea and Canadian Archipelago, respectively.

In Norway, images received by mid-December 1976 already indicated that snow accumulation on the ground exceeded by 50 percent the total snow accumulation expected for the entire winter. This was confirmed by ground measurements. As a result, Norwegian authorities expect to be able to generate more hydroelectric power than previously anticipated. (In early 1976, Landsat images of snow cover permitted government experts to predict that sufficient melt-water runoff would occur to refill power-producing dams in the spring. An additional $250,000 worth of electricity was thus generated and sold in the winter when this energy was needed, and the snow-melt runoff, which would have been discharged over the dam without creating energy, was instead used throughout the summer.)

Of the 11 known HRPT stations, two are privately operated. In Scotland, the University of Dundee's Electronic and Engineering Department, largely as a student project, constructed and is operating the only HRPT station in Great Britain at this time. Recently, the school received a two-year contract to receive and archive high resolution imagery for the Telecommunications Centre, after oil companies and others in the commercial, scientific, and academic communities sought assistance in obtaining high resolution imagery for special purposes. At Bochum, West Germany, an HRPT station was constructed shortly after HRPT data became available on a real-time basis; Dr. Heinz Kaminski, director of the station, has written numerous reports on applications of HRPT imagery.

Next to APT and HRPT, the Weather Facsimile (WEFAX) transmissions from NOAA's geostationary (GOES) spacecraft are of the greatest interest to the most people. Even though there are only seven locations at which this S-band transmission can be received, a rapid growth in receiving capability is expected in the near future because of the timeliness of the data and low cost of an S-band WEFAX station. Generally less than three hours old when received, the information is much more valuable than that obtained from other sources of WEFAX transmissions, which frequently include observations more than 12 hours old. A high quality GOES WEFAX terminal costs about $12,000, but Roy Cawthon, a ham enthusiast in Atlanta, Ga., built one for less than $3,000. Monte Hatfield of Palmetto, Fla., also built a station, with some help from a commercial company, for about the same price. Trinidad, Canada, and France each have a WEFAX station, while in the US, NASA's Goddard Space Flight Center and EMR Telemetry, a commercial company in Florida, both copy WEFAX for test and evaluation purposes.

France plans three WEFAX stations in the Caribbean and four for Pacific island possessions and territories. Several South American countries are modifying their APT stations for GOES WEFAX stations, while New Zealand and Australia are purchasing new equipment for this purpose.

Satellite direct readout has become a multinational program with significant economic, scientific and political ramification for all countries involved. Data applications touch on nearly all forms of transportation, as well as on hobbies and recreation, disaster warnings, energy generation, pollution control, food and agricultural production, plant and animal biology, civil and national defense, business economics, education, and others. The application of imagery for so many varied purposes represents a major demonstration of the peaceful uses of outer space, spear-headed by NOAA and its satellite service, NESS. □

THE VIEW FROM SPACE

A year ago, on July 29, 1976, NOAA–5 satellite was put into polar orbit from NASA's Western Launch Operations Division, Lompoc, Calif. Since then, NOAA–5 has completed about 4,500 revolutions around the globe, from pole to pole. The spacecraft has peered down on every spot in the world, and several of the more spectacular views it has captured are shown on these pages.

1 Aside from a few clouds in the Arabian Sea (left), India was enjoying a perfect weather day on March 13; so clear that one can see the Ganges River (top right), the Great Indian Desert and Pakistan's Indus River (top left), and the island of Ceylon in the Bay of Bengal (bottom right).

2 Clouds cover parts of Scotland and Ireland, but much of the British Isles stand in clear relief in this NOAA–5 image recorded at the Electronics Laboratory of the University of Dundee, one of the many sites around the world where imagery from the polar-orbiting satellite can be received.

3 Snow and ice were prominent features on April 9 when NOAA–5 passed over Scandinavia, which was virtually cloud-free. Ice clogs the northern part of the Gulf of Bothnia which separates Sweden and Finland, as well as the Gulf of Finland. But the Baltic Sea is open, as are waters around Denmark.

4 While scattered clouds obscure parts of Southern Japan, Hokkaido (top), most of Honshu, and Kyushu are clearly visible in this polar-orbiting satellite picture. North and South Korea and part of the Maritime Territory of Russia (upper left) are identifiable.

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3

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NOAA aids in sending foreign students on

A Flight to Knowledge

By VALERIE A. GILLEN

"If a man be gracious and courteous to strangers, it shows he is a citizen of the world, and that his heart is no island cut off from other lands, but a continent that joins to them."

Francis Bacon

THE young Indonesian stepped off the 727 and experienced the same feeling of excitement at the sight of the big airport as he had at his first sight of the airplane. Uncertain, he slowly moved toward the crowd of waiting people. Within moments, a pretty girl walked up and said, "Hi. Welcome to the United States. You must be Sutanto from Indonesia." He nodded yes with a brief sigh and the girl continued: "I'm Nancy, a volunteer from the Washington International Center, and I am here to insure that your stay in Washington is a pleasant one."

Sutanto is one of hundreds of students brought to the United States from approximately 80 developing countries to study at U.S. universities, Federal and state agencies, and private corporations. Some come under the Agency for International Development's (AID) Participant Training Program. Others are sponsored by the United Nations and its specialized agencies including the World Meteorological Organization (WMO) and the Food and Agriculture Organization (FAO).

United States involvement in training foreign nationals began during World War II. During the past ten years, 77 foreign nationals each year—on the average—have been trained in atmospheric sciences by WMO. In addition, 21 each year have been trained in aquaculture by AID; and 55 each year by FAO.

Sutanto was chosen to come to the United States to study aquaculture with the promise that he would return as a fish farmer back home.

His opportunity arose when the government of Indonesia made a request to AID for training opportunities for its citizens.

Under bilateral agreements with many of these countries, AID has agreed to contribute to their growth in technical skills and human resources through the training of some of their citizens in technical, professional, and managerial skills and in the attitudes and values that are believed to be essential to

social and economic development.

Because NOAA is the recognized government agency in the area of fisheries, Sutanto's request for training was sent to and administered by NOAA and its Office of International Affairs and their Technical Assistance Division.

He and his fellow trainees receive education to meet either long term or practical needs. Some participate in programs leading to a B.S., M.S. or Ph.D. degree—programs lasting up to four years. Others are brought over for practical training; they generally stay less than a year. All training is linked to specific developmental goals and projects necessary to the nation's economic growth.

The home country of a fellow occasionally either shares in or completely covers the cost of transporting him to the U.S.

The home country also pays his family all or part of his previous salary while he is in training. When he returns, his employer is also obligated to place him in a position that will utilize the training he has received.

An AID student's orientation begins with a welcome by volunteers from the Washington International Center. Operated by the Meridian House Foundation since 1961, the Center receives foreign visitors from many Federal, private, and international organizations including those in the AID Participant Training Program.

The volunteers assist students by helping them find hotel rooms, and scheduling a program of discussions about life in the United States—discussions ranging from how to use the telephone to how to order a meal in a restaurant. They also plan evening and community activities to encourage students to engage in social functions, as an introduction to the culture of the United States. The orientation at the Center generally lasts five days, during which time students participate in informal discussions on such topics as religious life, the family and community, and the school.

In many ways, NOAA's International Training Officers assist the foreign nationals. They help them cash checks, help work out program changes, assist them in getting airline tickets, and help them with personal problems. If a married student wishes to have his wife brought to the United States during his training, NOAA's training officers assist him in making the arrangements.

Aquaculture students, sponsored by AID, are met at the airport by volunteers from the

Dr. John Plumb (above) conducts a fish biology class at Auburn University; Dr. R. T. Lovell (left) discusses smoked fish with students from Cambodia and Nigeria; and Dr. E. W. Shell (below) and students sort fish.

Washington International Center, while those sponsored by the FAO or WMO are met by NOAA training officers. In either case, the orientation is similar. NOAA training officers act as a liaison for the students under their wing, and try to help them adjust to their new situation.

"It's very important to help them understand the local idiom and slang," says Fred Laney, NOAA International Training Officer for fisheries. "We had one student who was told, in a moment of light-hearted conversation, to 'go jump in the lake'. He thought that was what he was supposed to do, and was puzzled and, naturally enough, a little hurt. I explained the use of the phrase, and of others somewhat like it, so that he would be in a better position to cope with some of our everyday banter."

The NOAA training officers meet the foreign citizens during their first few weeks in the country. However, after they go to their designated colleges or facilities, the training officers remain in close contact with them and are available to help them with any problems or questions they may have during their training.

While in the United States, students are paid a per diem allowance. They receive free health and accident insurance and are provided with an allowance for books and training materials. Those whose programs are administered by NOAA are also briefed on their responsibilities to the program. They visit NOAA Headquarters in Rockville, Md., and tour appropriate NOAA facilities.

Students here to study aquaculture visit the aquaculture facilities of the National Marine Fisheries Service; those here to study satellite meteorology are given a tour of the National Environmental Satellite Service facilities in Suitland, Md.

Those not proficient in the English language are sent to language institutes such as the American Language Institute at Georgetown University, the University of Miami, or the University of Arizona. Students enrolling in degree programs need to be more proficient in English than do those on brief practical projects, such as learning the applications of fish farming. Their stays at the language institutes reflect this difference.

Under the Voluntary Assistance Program of WMO, NOAA each year offers six to eight long-term meteorological fellowships leading to a B.S. degree. Funds are provided by the State Department. NOAA also offers a large number of short-term fellowships with emphasis on the maintenance of meteorological and telecommunications equipment.

NOAA's training officers take great care in developing a program for each student that would fulfill the needs of each particular country.

When NOAA's Office of International Affairs receives from AID or WMO the candidate's credentials—consisting of transcripts of his academic record, English language proficiency test results, and work experience—it contacts a university to arrange admittance.

The foreign nationals selected must meet strict qualifications. They undergo a physical examination and must be individuals who have served well in some capacity or position within an organization that is high in priority in the social and economic development plans of their homeland.

A candidate must also be judged well-motivated and aware of the importance of the training and its place in his country's goals.

"The students we sponsor are highly motivated and carefully selected," said Martin N.

Rice and fish are grown together in the Philippines (above), and aquaculture research is conducted by Auburn trained staff with native Filipinos.

Rosenblatt, International Training Officer for Atmospheric Sciences. "To select a candidate for a WMO fellowship, the Director of a meteorological service in a developing country typically would consider not only the person's technical qualifications, but also his capacity to absorb new knowledge and skills, and his potential for communicating them to associates when he returns to his homeland. The foreign nations want to be represented by their best talent, and we want to train their best talent. So our objectives mesh, and we get highly motivated people."

In accepting a fellowship, a candidate obligates himself to serve his agency back home for two to five years.

At times, before the need for a particular kind of training is established, technical assistance programs are carried out in the country. The government of that country may have a problem that it does not understand or know how to resolve. The host country makes a request to WMO or AID and American technicans are sent there to assist in making a preliminary survey. They return with a report on the country's needs, and a full-scale technical assistance program may begin.

Training is an outgrowth of such a U.S. technical assistance program. Laney explains:

"If we have an American technician setting up a meteorological station," he says, "we know that there will be a need for trained counterparts—nationals of the particular country—to take over when he leaves." The American technician sends citizens of that country to the United States to be trained. When they return, they are qualified to manage and operate the station.

One such technical assistance program carried out by AID is upgrading aquaculture in developing countries. AID looked for a university with expertise in this area and selected Auburn University in Alabama. Auburn has gained a worldwide reputation for its aquaculture research and teaching programs in warmwater fisheries.

Under the AID program, Auburn sends experts to nations that have asked for help in developing aquaculture. The people from Auburn determine whether fish ponds can be built, and conduct research into the building, engineering and biological aspects of aquaculture in that area. If the projects show promise, citizens of the country go to Auburn for training in fisheries management, engineering, water quality control and biology.

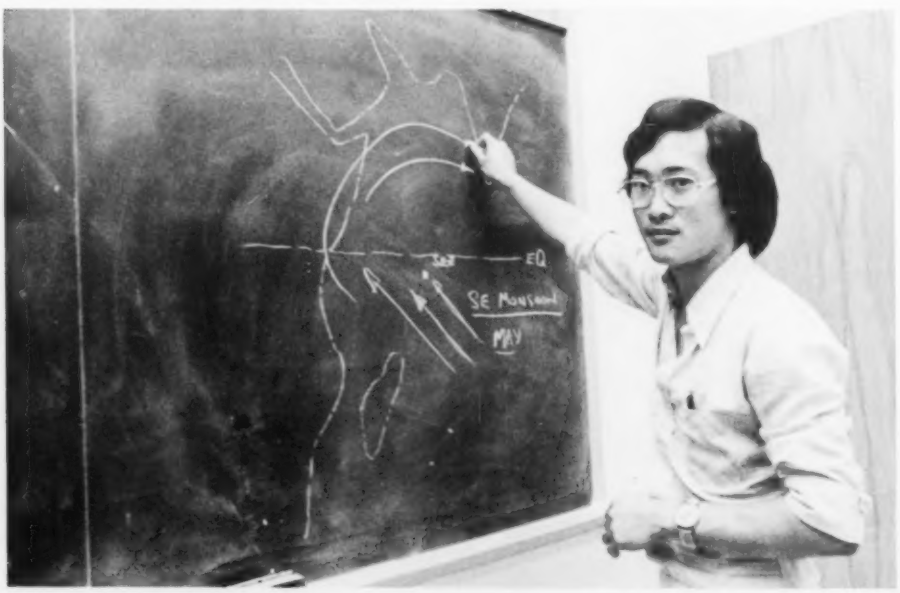
AID pays for this training, with the country contributing funds for the transportation of its people.

Because NOAA is the recognized U.S. Government agency in fisheries, NOAA acts as a liaison between AID and the university.

Auburn University received its first contract from AID in 1967. Several foreign nationals trained there have gone on to become high officials in their own countries. One former student is now Director General for Fisheries in Thailand; another is Dean of the College of Fisheries in the Philippines; most of the staff was also trained in Auburn.

Dr. E. W. Shell, Head, Department of Fisheries and Allied Aquaculture, and Director, International Center for Aquaculture, at Auburn University describes its program:

"Foreign students who come to Auburn go through the life of a fish farmer," he explains. "They are required to keep up with diseases, the killing of harmful fish, and the cleaning and maintenance of the fish ponds. The integration of classroom and hands-on training is what makes the difference. When they return to their country, they will be in a position to help their people."



Simon Lownam (top left) a Florida State University student from Seychelles, a group of islands in the Indian Ocean, monsoon winds; Cisse Hassane (left), a student from the Republic of Niger and Gibril T. Kanu, from Sierra Leone, study satellite pictures; and Saynam Virakone, a student from Laos, studies meteorological charts.

Fishermen in Brazil net their catch (above), later to be seen in Brazilian markets.

One Auburn student from Syria describes the importance of this training to his country: "Protein is very important for health," he says. "We need protein for our people. I am here to gain more knowledge and experience in the breeding and production of fish."

A married couple from Thailand is pursuing complementary programs at Auburn. She has a master's in fish nutrition and is working towards her Ph.D. He studies parasites and diseases in fish. When they return, she will be able to apply what she has learned by teaching Thai citizens about the diets of fish, and he will be able to help the fish farmers. They will work together to improve the methods of fish farming in their homeland.

Auburn University also offers a five month practical training program intended for participants from foreign countries who are employed as fishery officers, biologists, managers, planners and administrators, and who will be involved primarily in aquaculture related activities in their home countries. It includes lectures, laboratory, field work, and special projects. The students take trips to visit fish processing plants, fish feed mills, private fish farms, fish hatcheries, shrimp culture facilities, and extension agencies. Cultured species common to many of their countries are also available to Auburn.

On the other side of NOAA's expertise is atmospheric sciences. Requests for training in this area generally come from the WMO. Among the participating universities dealing with atmospheric sciences is Florida State University.

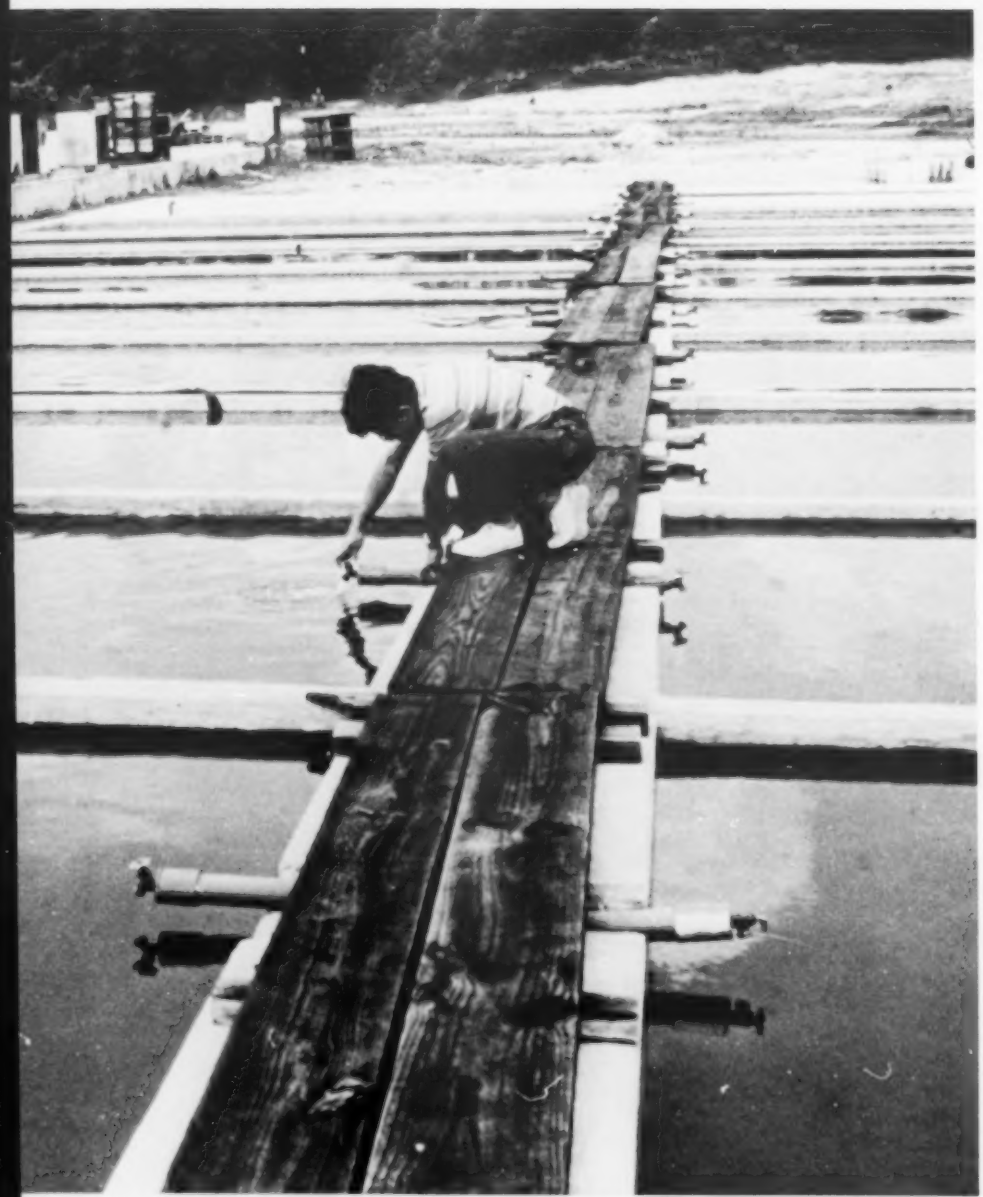
Jesse J. Stephens, Chairman of the Meteorology Department, describes FSU's meteorology program in relation to foreign students: "These students come with some scientific background and are aware of how they will fit within their weather service structure," he says. "They come with very definite ideas about the kind of training they need. Our function is to teach them how to continue their education. They can go back and continue to improve themselves. The practical side of meteorology comes easily if you get the basic background. We are doing a universal service to this nation and to the world. We are proud that we are making some impact in the science of weather around the world."

Many FSU graduates also have gone on to become experts in their countries. One became Director of the meteorological service in Niger. Another is Director of the meteorological service in Malawi. The Chief of Civil Aviation for the Agency for the Security of Air Navigation for Africa is an FSU graduate. Kendrick Leslie, an FSU student working toward his Ph.D. degree, is presently Director of the meteorological service in Belize in Central America.

He explains the importance of his training at FSU: "I came here to use the data from hurricanes Fifi and Carmen to help improve the agrometeorological and hydrometeorological program in my country," he says. "The training is invaluable. I have received a lot of personal satisfaction and exposure in new techniques that I would not have been able to develop back home.

"We will soon be able to develop further rainfall statistics for the Caribbean," he continues. "Rainfall can make or break an economy—especially in the area of agriculture. There just isn't much that has been done in my country."

Another foreign citizen, from the island of Mauritius in the Indian Ocean, came to FSU to get special training in trade winds. "My country is in the trade wind belt," he says. "We have trade winds nine months out of the year. There hasn't been much continuing research done in the Indian Ocean. I have 100



A Filipino student checks the water in concrete ponds at Auburn (left); and students examine spawning boxes for eggs after the fish have spawned.

years of data to sort out. We lack research, the ability to analyze maps and forecast weather. This training will help my country in aviation and in agriculture."

Since he has been at FSU, he has learned how to do American modeling, computer and numerical work. He has learned how to study the structure of the weather and how he can implement that knowledge in his country.

A student from Sierra Leone feels that studying Florida weather will help him learn to forecast for his country's tropical weather.

A pan-African school of meteorology in the Republic of Niger, is working with U.S. and United Nations assistance to deal with the drought in Africa's Sahel. Sponsored by OCAM (the Organisation Comunal Africaine et Malgache), the school was founded in 1964, and has sent students to Florida State University for specialized education that it is not yet in a position to offer.

Some of the foreign nationals are in the U.S. to study general meteorology. One student from Seychelles—a group of islands in the Indian Ocean—studies climatology. He says they have to generalize so that he can work across the board. He says his country has little specialized information; their stations are spread out across the islands.

Some encounter problems in adjusting to a new way of life. However, generally speaking, the advisors and professors of these students feel that they learn to accommodate quickly, that foreign students tend to be more motivated and work harder than Americans.

Most of them have handled family problems very well. A married student from the Philippines says, "I miss my family, and sometimes become frustrated when I cannot talk to them. But, I feel my family is close to me. I know that we will be more bonded when I return to compensate for the time we were apart. One consolation is that in the long run we will be helping our people."

Another, from Senegal says it another way: "I miss my family, but I realize that it is only a matter of time. You have to miss some things in life in order to have other things."

Some may also experience personal pressures from home that make it difficult to study. Two students have experienced concern regarding major changes in the government of their countries since they left. They are not sure where they will fit in when they return.

Some have a language problem. One citizen from Bolivia says, "sometimes you are anxious to know something but you cannot express yourself."

Dr. Donna Blank, Assistant Professor of Meteorology at FSU says, "The foreign students should be prepared to learn the local idiom in order to communicate in class. My experience has been that they adapt and handle the material well. Some of our best students are foreign nationals."

When Sutanto and his peers step back onto the plane after four years, they will not only have experienced a flight to knowledge in meteorology, fisheries, or whatever else they may have come to study, but with the help of NOAA's International Affairs Office, they will have learned about the lifestyles of other peoples of the world—a knowledge that will benefit them and their associates for years to come. □

The Meteorology of Air Pollution

By CARL A. POSEY

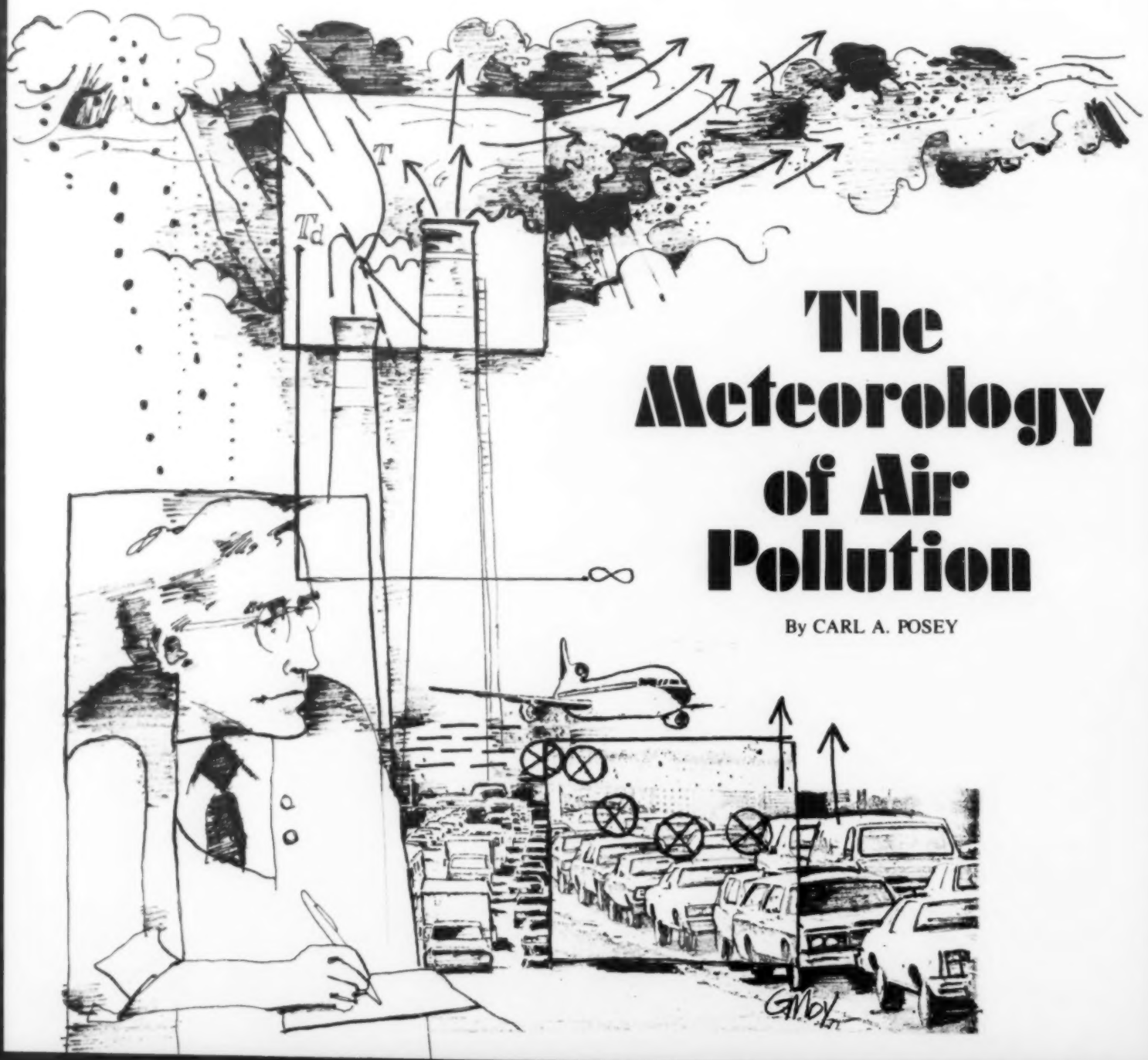
TAKE a few billion molecules of assorted hydrocarbons, oxides of nitrogen and sulfur, and the like, and exhaust them into the atmosphere; and then, an hour, a day, a week later, inhale what the wind and weather, sun and atmospheric chemistry have done to them. Everything between the emission and the inhalation involves meteorology—the meteorology of air pollution.

This is a meteorology concerned mainly with city-sized atmospheres—a layer of air from the ground to a height of a few thousand feet, an area perhaps 50 miles across. Even as science, this meteorology is not the familiar routine of analysis and forecasting. Instead, it focuses on the transport and dispersion of pollutants in the air, the behavior of smoke plumes, the chemical transformations wrought by solar radiation, trajectories, and—one of many bottom lines in the trade—the role of weather in the way various types and quantities of air pollutants affect human health.

Much of the air pollution meteorology effort of the Federal Government is carried out by a facility tucked into the abundantly meadowed and treed area between the North Carolina cities of Raleigh, Durham, and Chapel Hill called Research Triangle Park. There, modern office and laboratory buildings thrust skyward from the Piedmont countryside, concrete towers rising alongside mature pines and the old-timers of a deciduous hardwood forest. In that setting, in a building shared with the National Center for Health Statistics, NOAA's Meteorology Laboratory conducts its pursuit of the elusive properties of air pollution.

Air pollution meteorology is both older and newer than conventional wisdom would have it. It began at the national level at a time when one had to visit Los Angeles or Pittsburgh or Gary to see the term in action. On the other hand, a science for which the old days mean the mid-1950's still must be considered young.

Lawrence E. Niemeyer, the large, jovial man who directs the Meteorology Laboratory, was one of a handful of pioneers in that effort. "It came into being," he remembers, "as part of Public Law 159, back in 1955. Three meteorologists were assigned from what was then called the Office of Meteoro-



logical Research in the Weather Bureau. Ray Wanta was meteorologist-in-charge.

"That's really before many people think much attention was being paid to air pollution by the federal government. Of course, three meteorologists don't constitute a lot of attention. As a matter of fact, the federal program budget in those days was less than many state air-pollution programs, like California's. Smaller, I think, than the program for the city of Los Angeles. As the years have gone by that's turned around dramatically, of course."

What is now the Meteorology Laboratory began in Cincinnati in July 1955, as a Weather Bureau Research Station attached to the Department of Health, Education and Welfare, the air-pollution effort was eventually called the Community Air Pollution Program of HEW; Robert McCormick became its director in 1958. "We stayed in Cincinnati until the summer of 1969," Niemeyer says, "and that summer we moved to North Carolina."

Soon after its arrival in North Carolina, the lab went through another set of organizational changes. The National Air Pollution Control Administration, the HEW unit to which the laboratory was detailed, became part of the Environmental Protection Agency when that organization was formed in 1970. At about the same time, the lab's parent organization became NOAA, and the North Carolina facility became one of the Air Resources Laboratories, part of NOAA's Environmental Research Laboratories.

The Meteorology Laboratory may be unique in the degree to which it belongs to two agencies. On the one hand, its research people make up a division—the Meteorology and Assessment Division of the Environmental Science Research Laboratory—within EPA, and, Niemeyer notes, the day-to-day assignments come from the EPA side.

On the operational side of the laboratory, NOAA people share the air-pollution trenches with their EPA colleagues. Meteorologists from the lab are assigned to the EPA regional offices, two EPA laboratories in Nevada and Oregon, and to the Enforcement Division of EPA headquarters. Specialists from the laboratory provide the meteorological expertise needed to develop and enforce air quality standards, and the tools and techniques state and local air quality people need to make their own assessments of specific pollutors and pollutants. The Meteorology Laboratory is effectively the weather arm of the EPA, which supports it at a rate of several million dollars a year.

Antiquity, in this young science, is probably the time before there were computer models. These coded physical descriptions of the air and its cargo of pollutants pervade the work of the laboratory, which has the stature of an institutional Daniel Boone among air-pollution modelling pioneers.

Bruce Turner directs the Environmental Applications Branch—the laboratory's model shop, in the retail sense of the term. "We're mainly concerned with technology transfer," he says, "taking products developed by researchers and trying to put them into the hands of the users."

What is being transferred is a family of atmospheric dispersion models, which, once set in motion in a computer, describe how emissions from a pollutant source will move through time and space.

"These permit us to estimate air quality levels in a number of different situations," Turner explains. "We can do this for an urban area, for a remote powerplant out in open country, and, to a limited extent, for polluting sources in complex terrain."

Their audience comprises technical and environmental managers, people, who, Bruce points out, can assess their problem and their model results, once they know what inputs to use. "We serve as a focal point for such people. What we discuss with them is which model they need, which models won't work in their particular situation, and how to apply the model to solving their problems. We also learn about the problem they're facing."

The models available from Turner's group serve a select, but surprisingly large clientele. In 1976, for example, 105 different groups purchased UNAMAP (from User's Network for Applied Modelling of Air Pollution) tapes of the six models now available on that network, through the National Technical Information Service. These clients included 49 consultants in 22 states, 27 industries in 16 states, 12 universities in 10 states, 13 government agencies in nine states, and four foreign nations: Canada, England, Norway, and Japan. When the models are improved, UNAMAP users are notified and may purchase an updated tape. The models are also available through a nationwide computer network called INFONET.

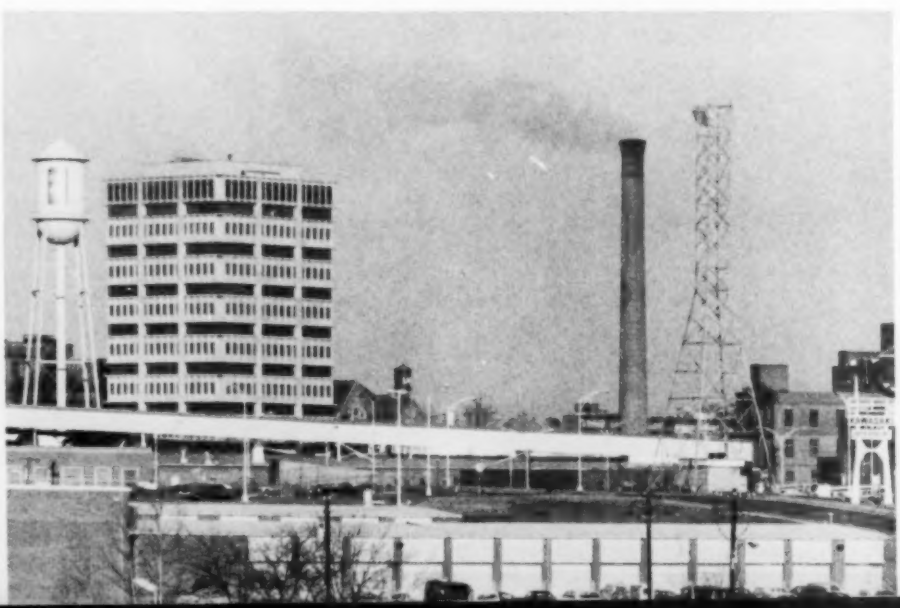
This, Turner says, is just a beginning. "The six models we have on UNAMAP," he explains, "are only capable of handling five to fifteen percent of the pollution problems our users have to solve. And none of the six on UNAMAP is for complex terrain."

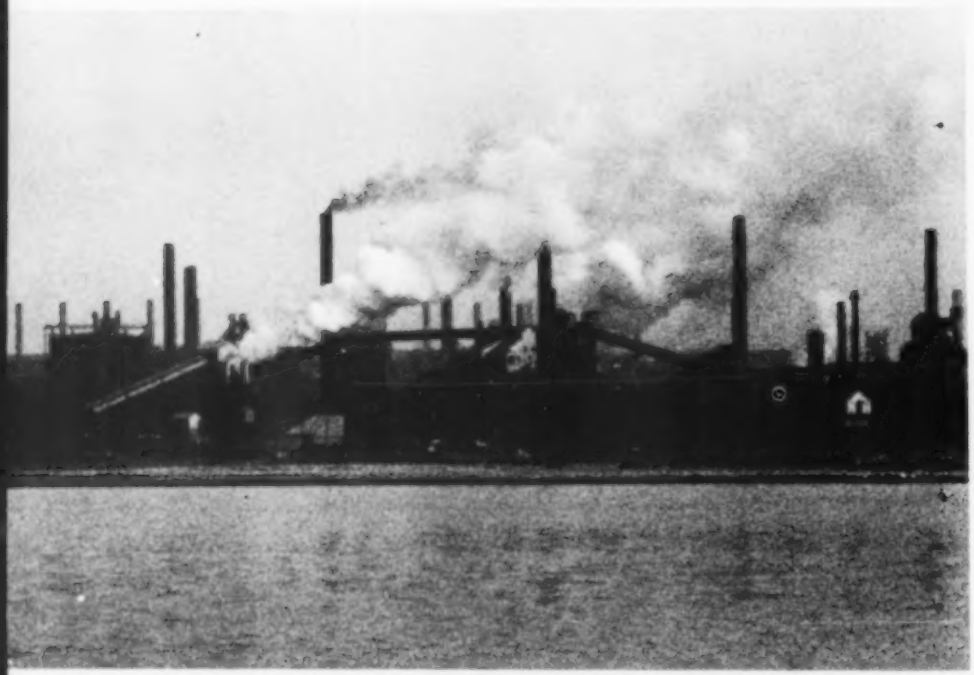
Still, in a technological world where the objective of virtually every scientific investigation is a descriptive or predictive model, seeing models on the shelf in North Carolina is a look at the future of those sciences still trying to get that first tape together.

But, as Turner points out, the off-the-shelf models are only a beginning. The laboratory also runs a major model development effort, one that is attempting to make the jump from simple Gaussian models—models based on probability distributions—to their vastly more sophisticated numerical cousins.

Dr. Kenneth Demerjian, who leads this small group of "non-Gaussians," describes the build-up of their models. "The idea," he says, "is to take emissions as they come out of point sources, like a smokestack, or area sources, like a community, or line sources, like highways . . . and put them into a three-dimensional grid. Then we overlay these emissions with meteorology—mixing, dispersion, and transport. Then we add the chemistry to describe how the emitted pollutants are chemically transformed. We end up with a set of partial differential equations describing diffusion, advection, deposition, transformation, the whole works . . . then solve them numerically, hoping that the physics and chemistry we've put into the problem are correct, and that the mathematical representation is cor-

Lawrence E. Niemeyer is director of the Meteorology Laboratory, a NOAA facility that is also EPA's meteorological arm. Below, the operational branch of the laboratory is housed in a new building among cigarette factories in Durham, N.C.





Two versions of smokestack pollution plumes—an actual condition (above) and a wind tunnel model (below), showing tall stack versus short stack effects downwind of ridge.

rect. We solve these for each grid point as a function of time. The idea is to simulate the air-pollution process, on local, urban, or regional scales."

But numerical models force some trading, Demerjian admits. "Our models aren't as easy to use, and it may be that people out in the field would be reluctant right now to try to work with a numerical model to solve their problem. But the fact is we can address complex problems that the Gaussian plume model cannot."

Demerjian, and others in his specialty, believe modelling provides a useful tool for planners and regulatory people confronting a given air-pollution problem. "On the other hand," he says, "a lot of people think modelling's just a waste of time. Thus far, the results we have are very superficial in terms of verified models. They seem to work, and the indications are that we can get the accuracies we need. What's lacking is a detailed verification program to assess model performance."

For some models, such a program is right around the corner.

If there is a term as pervasive as "model" at the North Carolina laboratory, it is "RAPS," the acronym for Regional Air Pollution Study, an intensive, five-year-long look at air pollution in and around St. Louis, Missouri. The study is to the modelling of urban air-pollution and meteorology what 1974's GATE was to modellers of tropical meteorology—the first set of data comprehensive enough to test how well models stimulate the real world.

Dr. Jason Ching, also of the modelling branch, has been close to the meteorological field work involved in RAPS. "People in the field have been careful to obtain measurements that will permit researchers to explain the turbulent transfer processes in the non-homogeneous, non-stationary conditions prevailing in urban areas," he says. "The resulting data base, and the insight gained, should provide for more physically consistent model development."

RAPS, according to Dr. Francis Pooler, ends this year after a cost to EPA of about $25 million. The experiment was designed by model developers, and effectively transformed the greater St. Louis metropolitan area into an instrument array, with surface stations, mobile vans, and aircraft taking the broad meteorological and air-quality measures of the St. Louis sky. Why St. Louis? "We picked it," Pooler explains, "because it offers lots of emissions, both from vehicles and heavy industry, its topography is relatively simple, there's no shoreline to complicate urban meteorology—and it's isolated from major sources upwind. Also—and this is vital—the St. Louis region in both Missouri and Illinois has strong, active pollution-control efforts already in place."

Pooler is one of the original three meteorologists assigned to the air-pollution group in Cincinnati in 1955. Before that, "I did rain dances, was an observer and briefer. In Washington I worked on atomic fallout. As a matter of fact, much of what we do in air-pollution meteorology evolved out of our radioactivity work, where we learned to model trajectories, dispersion, rainout, and the like.

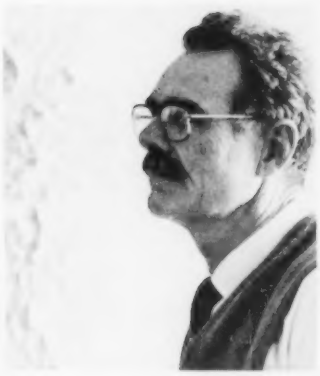
"In the old days, modellers were mainly mathematicians. But they don't think of conservation of energy and mass in the same way meteorologists do, and so meteorologists began doing some of the modelling too.

"This is certainly not synoptic meteorology. But you have to use any scrap of knowledge you bring to the job. You have to understand climatology to know whether you can generalize, for example. It's still a new field. It combines micrometeorology, interactions at all scales of motion in the atmosphere, from cloud physics to diagnoses on the microscale. It makes you realize how inadequate your knowledge really is."

This realization of inadequacy is crucial to the modelling work in Demerjian's Atmospheric Modelling and Assessment Branch. "We'll be using the RAPS data to verify eight or ten air-quality simulation models, some developed here, and some developed by other organizations, like Lawrence Livermore Laboratory," Demerjian says. "We want to answer the question, Do they work or don't they, and, if they do, how well?"

Demerjian's group keeps a number of models in development. One of them is a photochemical model that simulates the chemical reactions of precursors like hydrocarbons and nitrogen oxides as they are photochemically transformed into oxidants like ozone.

"We're also working on a box model," he says. "In this approach, most of the spatial complexities of the meteorology and emis-



Pollution probers . . . (l. to r. by row from the top) Dr. Kenneth Demerjian, director, Atmospheric Modeling and Assessment; Jim Dicke, director of the Durham unit; George Holzworth, head of Geophysical Research Branch; Dr. William Snyder; Robert Frankhauser; Dr. Francis Pooler, Regional Air Pollution Study (RAPS) coordinator; Dr. Jason Ching; Karl Kurfis; Larry Truppi.

sions have been averaged out. It's like visualizing an urban area as a well-mixed flow reactor. The emissions coming from the bottom of the box make up the major source of mass inflow of pollutants. The meteorology—wind speed and varying mixing height—makes up the major source of outflow, or dilution. The chemical transformations are simulated while the pollutants are in the box. The spatial simplicity allows more detailed treatment of the chemical kinetic processes than is economically feasible in the more spatially resolved grid point models."

In approaching operational models, however, everything is economics. "Models should permit us to look at separate solutions, evaluate control strategies, and find the best and cheapest way to achieve the ambient air standards," Demerjian says. "If they do that, they'll be very beneficial.

"On the other hand, the kind of high-resolution inventory of emissions we have for St. Louis cost considerably more than you can reasonably expect a state agency to spend. The RAPS emissions inventory gives us sources and the pollutants they contribute hour by hour. If our models don't work with lower resolutions, I imagine some cost-benefit analysis will be in order.

"The point is, we have to learn at what point the benefit of modelling stops making sense in terms of the economic cost involved in the decisions it is supporting."

There are real-world quantities in this group that don't flow from RAPS, at least at some scales of time and motion. A mile or two away from the main laboratory facility, a long metal shed rises from a clearing in the pines and hardwoods. This is the Fluid Modelling Facility, one of only a few atmospheric dispersion modelling facilities in the world. A water channel and towing tank, a meteorological wind tunnel, and an instrument calibration wind tunnel are the major elements of the facility, which also includes such supporting work as a model and electronics shop, chemical lab, and a darkroom.

A characteristic experiment uses the water channel to study the rise of a buoyant plume. The "atmosphere" is salt water, the stratification simulates night time conditions in the real atmosphere—a time when light winds and little vertical mixing cause plumes to spread out horizontally. Later, the morning

Pollutant Standards Index (PSI)

I	II	III					IV	V	VI
		POLLUTANT LEVELS							
INDEX VALUE	AIR QUALITY LEVEL	TSP (24-hour), $\mu g/m^3$	SO_2 (24-hour), $\mu g/m^3$	CO (8-hour), mg/m^3	O_3 (1-hour), $\mu g/m^3$	NO_2 (1-hour), $\mu g/m^3$	HEALTH EFFECT DESCRIPTOR	GENERAL HEALTH EFFECTS	CAUTIONARY STATEMENTS
500	SIFNICANT HARM	1000	2620	57.5	1200	3750			
								Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic.
400	EMERGENCY	875	2100	46.0	1000	3000	HAZARDOUS		
								Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
300	WARNING	625	1600	34.0	800	2260			
							VERY UHEALTHFUL	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity.
200	ALERT	375	800	17.0	400[c]	1130			
							UNHEALTHFUL	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population.	Persons with existing heat or respiratory ailments should reduce physical exertion and outdoor activity.
100	NAAQS	260	365	10.0	160	*			
							MODERATE		
50	50% OF NAAQS	75[b]	80[b]	5.0	80	*			
							GOOD		
0		0	0	0	0	*			

* No index values reported at concentration levels below those specified by "Alert Level" criteria. [b] Annual primary NAAQS. [c] 400 $\mu g/m^3$ was used instead of the O_3 Alert Level of 200 $\mu g/m^3$ (see text).

sun would introduce heat and turbulence from the ground up, and this would overtake the plume and mix it down to the surface. So, Dr. William Snyder, who directs the fluid modelling facility, Karl Kurfis, and Lou Knight, are adding a blue fluid to an atmosphere of stratified salt water, to see how fast the plume rises and how fast it spreads.

It is one of a family of experiments that includes diffusion among buildings, deposition of pollutants, smokestack plume dynamics, studies of complex "topography." How well do these physical models simulate the real world?

"Simulation is a matter of scale," Snyder says. "My feeling is that we have good confidence in simulating flow around buildings, working at a scale of about one to 200, over maybe five or six city blocks. Mathematical models are fine for describing diffusion over an infinitely flat plane. But in the real world you have buildings, hills, moving vehicles, and so forth, that are difficult to describe mathematically. We think we can build models and simulate flow and diffusion more as it is in the atmosphere. As what we want to model increases in size, our confidence decreases—for example, wind speed must increase, and there are limits. But part of our mission is to discover what whose limits are. Nobody here thinks you can do everything in a wind tunnel."

The models themselves are rough equivalents of the real world—toy automobiles, pyramidal blocks for hills, oblong blocks for buildings. But they work. For example, Snyder remembers a study for the Rural Electrification Administration that saved a lot of money and modified some conventional wisdom regarding smokestacks.

"We put an idealized model into the wind tunnel to see what influence the building had. It turned out that a stack one and a half times the building height was okay, whereas the standard rule was two and a half times building height. So they went to a 450-foot stack instead of the 750-foot one, at a cost of $5 million instead of $15 million."

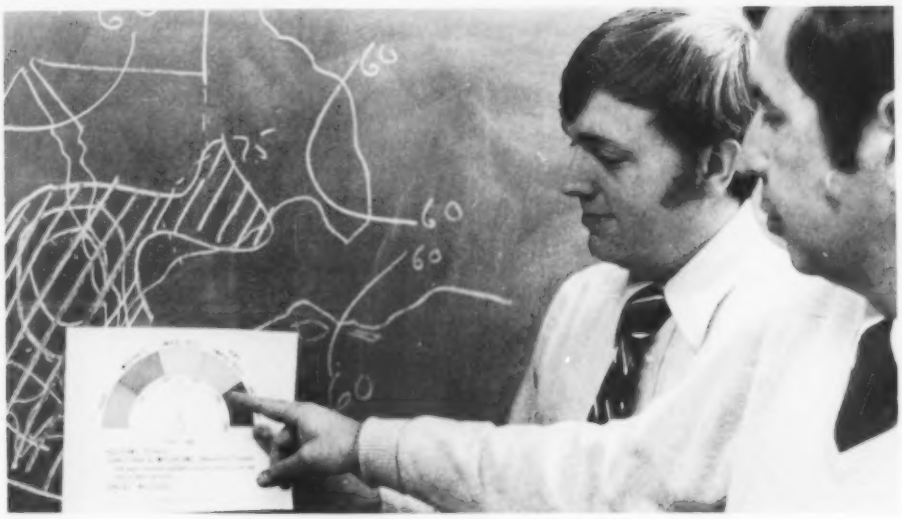
The wind tunnel is mainly used to model buildings and complex topography. But it can also test a highway model, a large turntable on which 1/25 scale toy automobiles travel on an endless chain across a surface, then around a sharp loop and back on the other side, like ducks in a shooting gallery. The automobile models are rigged to emit smoke as they cross the table, which can be rotated to provide any desired wind direction across the "highway."

Opened about three years ago, the wind tunnel was joined by a water channel about a year and a half ago. Since there are other wind tunnels and water channels available to do this work for the private sector, users are mainly government agencies, with some from the state and local levels. Future plans now are to provide for a closed air return in the wind tunnel and add heating and cooling to permit stratified situations similar to those available now in the salt water tank.

In the meantime, Snyder and his colleagues will continue their efforts to simulate air-pollution dispersion in the real world.

For George Holzworth, who leads the laboratory's Geophysical Research Branch, this real world is mainly a place of complex terrain and pollutant plumes. One of the branch's projects is to study how emissions behave when they leave the Clinch River powerplant in southwestern Virginia. The $700 million facility there has two 341-foot chimneys, and burns coal with only about .7 percent sulfur, quite low for eastern coal. A series of field measurements, made by a contractor, measures meteorological and pollutant elements at various distances from the plant. The purpose of the work, Holzworth notes, is to define the additional problems of air-pollution modelling that are introduced by complex terrain.

Plume rise is a term one hears a lot of at the North Carolina laboratory, and smokestacks are a major preoccupation. This is natural enough, since, at least on the industrial side of the air-pollution problem, smokestacks are primary sources of pollutants. Plume rise refers to the buoyancy effect of most plumes to rise to some equilibrium point above the level of the chimney which emits the plume. It is an important quantity because pollutant concentrations at the ground vary inversely as the square of the height of the



NOAA's E. L. Martinez (foreground) and EPA's Bill Hunt review sample television presentation of a new pollutant standard index, which rates five key pollutants on a common scale of 100 to 500.

plume centerline above the ground near the source. These are quantities Demerjian's group is interested in simulating mathematically and physically. In Holzworth's group the emphasis is on developing a climatology of plume rise.

"We went to the National Climatic Center in Asheville," he says, "and asked them to summarize rawinsonde soundings in terms of atmospheric temperature and wind structure. Then, we provided input data for the size of the chimney, the emission rate, and the temperature of the effluent, so they could calculate the plume rise for that chimney height according to the measured wind and temperature profiles. At the same time we had Asheville determine the percentage frequency that the plume was within, below, or above an inversion."

"This kind of climatological data provides considerably more information than that which is usually based on the assumption that atmospheric conditions measured near the ground prevail throughout the layer through which a plume rises. For example, inversions act to inhibit mixing, so when the plume is above the inversion it does not readily diffuse down to the ground; below an inversion, the plume is confined to the layer near the ground."

Inversions, in which warm air overlies cooler air, are the keystone of air pollution, at least in the popular view. The plume-rise climatology has also produced a comprehensive inversion climatology, and Holzworth is firm on the fact that you need more than an inversion to get a polluted atmosphere. "There's nothing especially sinister about inversions," he says. "Most places have them every night. The problem is emissions."

Holzworth's group is also working on new concepts in air quality standards. Visibility, for example. "EPA is interested in the possibility that visibility can be used as an air quality standard—and also a new standard for sulfates. In meteorology we're looking at the relationship between visual range and light-scattering measurements. Many of the more effective light-scattering particles are believed to be sulfates. We're also looking at natural haze producers, like the turpines that pine trees emit as a hydrocarbon, a photochemical precursor that forms ozone and particulates, and incidentally causes the blue haze over the Appalachians."

Where air-pollution problems have a shorter fuze, and may be solved by research (as distinct from service), the laboratory uses specialists from Bruce Turner's branch. Ralph Larsen is one of these "honorary meteorologists." His specialty is in the area of pollution effects, and he is credited with developing a novel statistical system for modelling air pollutant concentrations against averaging times. Larsen holds the equivalent rank of a Navy captain, and is one of two Public Health Service officers at the laboratory. When he began he was working with HEW, which is the parent organization of the Public Health Service; but ensuing reorganizations have cut him off from those roots, leaving him a kind of technical displaced person attached to two newish agencies, NOAA and EPA.

Robert Fankhauser, assigned to the EPA's Environmental Monitoring and Support Laboratory in a Research Triangle Park structure familiarly called "the Fort," works with EPA field studies. Recent work there has included analysis of ozone measurements at a number of middle-sized American cities, and investigations of such environmental problems as kepone, the dumping of iron ore tailings containing asbestos in Lake Superior, ocean incineration of pesticides, and air quality near vinyl chloride plants.

Lawrence E. Truppi is detailed to EPA's Health Effects Research Laboratory, also in the Fort, where he has come to specialize in studying the role played by weather and air pollutants on human health. This role, it turns out, can be substantial, and given to unexpected turns.

"We found that temperature has a big effect on mortality—that is, that you can't evaluate mortality during a pollution episode without considering air temperature," Truppi says. "Asthma attack goes up when it's cold, cardiovascular disorders go up with heat, especially angina pectoris. And it isn't just mortality. You have to consider morbidity—air pollution that sickens but doesn't necessarily kill."

A series of air pollution morbidity studies is underway. Four communities at different locations in the Los Angeles Basin are being monitored, under contract, in an effort to identify relationships between pollution and respiratory problems, chromosome damage, and other health effects. A similar study is planned for northeastern Ohio. The number of variables, and a general dearth of data connecting weather and health, make the work time-consuming and difficult. "You have to go into a population," Truppi says, "recruit a group, and check their symptoms day to day against variations in air pollution and weather elements.

"It takes a long time to collect mortality data, and weather isn't included on death certificates. Everything is more or less done by hand. But eventually we should have a mortality data base for the United States that includes the effect of temperature, and we'll be able to predict daily mortality in terms of air quality."

The fourth branch of the laboratory is billeted in Durham in a gleaming office tower set down amongst the cigarette factories there. Most of the signs say EPA, but there is a NOAA presence here, where a lot of the science behind the nation's air-quality control strategies gets done. Jim Dicke, who directs the NOAA unit, explains their work.

"We're the operations side of the Meteorology Lab," he says, "in contrast to the research side. We provide technical assistance to state and local programs when they have special problems—for example, when a particular source is coming into a region, and they want to evaluate its air-quality impact. Or sometimes a regional office just wants some moral support on a difficult decision. Sometimes we go over state or local control agency computer runs sent in by one of the EPA regional offices and suggest changes. Sometimes we actually go out and install the models in their own computer systems for them. We're also called upon to describe the state of air-quality modelling and to inform people about what models we're going to use."

This front-line world is quite different from the more neutral one of research. Here the sources are real, the problems those of developing control strategies, providing testimony, seeing that new models of things like deposition and mobile sources find application in the work of promulgating standards of air quality. "We provide support anywhere there is a meteorological connection," Dicke says. "To promulgate air-quality standards you need health and control information, and these are put together at the EPA technical center at Research Triangle Park. We help EPA determine ways the source should be controlled."

The Support Branch in Burham is attached to EPA's Office of Air Quality Planning and Standards, where a collaborative effort between NOAA and EPA specialists has led to a pollutant standard index for the five key pollutants—sulfur dioxide, total particulates, carbon monoxide, nitrogen dioxide, and oxidants. According to EPA's Bill Hunt, the index provides a unified hybrid that combines the attributes of indices used by many different states and communities. "Air quality index reporting in the past has been a very creative medium," he says, "and no two indices were found to be the same. So we attempted to retain as many common features as possible, then combined those with health effects. The result, we believe, is an index most states will eventually adopt, and many already have."

The new index is designed to convert the maximum measured daily air pollution level in a city to a simple number on a scale of 0 to 500. Intervals on this scale are related to the potential health effects of the daily measured levels of pollutants. The air pollution intervals and their health effects terms range from "good" (0 to 50), to "hazardous" (above 300). An index value of 100 corresponds to the short-period National Ambient Air Quality Standards; an index value of 500 indicates the "significant harm" level established by EPA.

E. L. Martinez, a NOAA colleague of Hunt's, helped develop the index, particularly ways to forecast index values from one day to the next. He also collaborates with his EPA co-workers to identify trends in the quality of American air.

How are we doing?

Better. In *National Air Quality and Emissions Trends Report, 1975*, one finds that:

An estimated 49 million people were exposed to total suspended particulate levels exceeding the annual primary standard in 1974, down from 73 million people in 1970; about seven million fewer people in the New York-New Jersey-Connecticut area were exposed to concentrations exceeding the primary health standard in 1974 than in 1971. Sulfur dioxide has been reduced dramatically. Photochemical oxidants show a little improvement in places like the Los Angeles basin, but show decreases in most cities east of the Mississippi. Carbon monoxide is declining nationwide.

Problems persist, of course. Martinez points to oxidants in summer as an example. "These oxidants are formed from precursors like nitrogen dioxide and hydrocarbons emitted by automobiles and stationary sources. Weather plays a very important role here, in summer. Slow-moving areas of high-pressure move through, so that, once formed by reactions with sunlight, oxidants tend to persist and build up over periods of days. In the eastern United States, several periods in a summer can exceed oxidant standards over tens of thousands of square miles. We've been studying this in the field, to help devise control strategies for cities and regions."

Primary standards for key pollutants are based on how they affect human health. Ozone mainly affects the human respiratory process when levels exceed .08 part per million, which is the quantity (for one hour in a year) used to establish the national standard. A series of field programs, conducted in the past several years under contract to EPA, assessed photochemical concentrations in various regions around the nation.

Enforcement of the standards is carried out even closer to the front than Durham, by ten EPA regional offices. Seven of these have a NOAA meteorologist on detail, administratively linked to the North Carolina lab through Bruce Turner's branch.

"They're there to work with the EPA region to solve any problems connected with air-pollution meteorology," explains Larry Niemeyer. "They may be called upon to evaluate the performance of an existing source of pollution, to determine whether or not it's meeting standards, to see whether additional control action needs to be taken. They may be asked to evaluate a new source that's been put in, what the ground-level concentrations will be, and what the impact will be on the air-quality standards of that region."

One of the problems, Niemeyer finds, is recruiting. "It's a fairly specialized kind of work. Basically we look for people who have solid academic training—a master's degree or Ph.D. . . . and general meteorological experience, so that they're aware of what the atmosphere does, how it acts. Then, specifically, we look for any environmental experience, particularly in the air-pollution field. It's this last quality that's most difficult to find."

But not as difficult as finding final answers to air-pollution problems; for here, as everywhere scientists work to assess the influence of human activities on the environment, and the answer to a question is almost never the obvious one. The problem peels like an onion—one is never quite finished.

"Sulfur dioxide is a case in point," Niemeyer says. "The switch to low-sulfur coal in some cities, replacement of obsolete factories with environmental controls, and other factors have dramatically reduced the amount of sulfur dioxide in the atmosphere. Three years ago, I might have added that this reduction of sulfur dioxide would ease a health problem. Now I'm less certain. It looks as if the culprit is not sulfur dioxide but one of the products that occur as a consequence of having sulfur dioxide in the atmosphere—sulfates. Sulfur dioxide is emitted as a gas, but transformed to sulfates in the atmosphere. Sulfates are particles, small enough to be ingested deep into the lungs. And sulfates are not decreasing in cities. So in a sense we trade one problem for another as our understanding improves."

The reason sulfates are not decreasing appears to be that they are coming from somewhere else, possibly the big, isolated coal-fired powerplants that have begun to dot the American map. Thus, sulfates connect to another freshly visible pollution problem—long-range transport. "You reach a point where you can solve the local problems," explains George Holzworth, "but what about a hundred miles downwind? There you could be making the problem worse. We're building larger, taller chimneys all the time, and taller chimneys have higher emission rates. The higher you release emissions, the longer they tend to remain airborne, and the more time there is for gaseous sulfur dioxide to form sulfates before the material is returned to ground level at some point downwind. It appears that's what's happening in our acid rainfall in the northeast."

And there are the new problems that sometimes spring from what seem to be solutions. The ubiquitous automobile offers an interesting example. "EPA a few years ago was thinking of what are called transportation control strategies," Niemeyer recalls. "These would reduce auto emissions by sharply reducing the amount of private automobile traffic. That was not a very popular approach.

"The approach that's now being used is to control carbon monoxide and some of the other effluents from automobiles in order to reduce the problem locally. But that is a long process and presents difficult engineering problems. You open the hood on a new car and you see all those pipes running different ways, to control emissions."

Then, a couple of years ago, the catalytic muffler, which chemically destroys certain compounds, was endorsed by the EPA as a likely solution to the problem of emission control, and major automakers began installing the devices on new cars. "At about this time," Niemeyer says, "the question was raised that the mufflers, while controlling some emissions, would themselves release pollutants—for example, sulfuric acid—into the atmosphere. Now this is a subject of several research programs, to determine exactly what a catalytic muffler does emit, and what the impacts of those emissions are on human health."

A problem of that magnitude tends to saturate the system at the Meteorology Laboratory. Bruce Turner's branch provided rapid response to compute estimates of how acid emitted by catalytic mufflers would impact people living near highways. Russ Lee and others in the Office of Air Quality Planning and Standards were called upon to help define the problem. These first estimates helped establish and refine agency policy. In time it was found that there are many different types of catalyst devices, some of which emit hardly anything. Ken Demerjian's group responded to the problem with a numerical model that simulated the catalyst emissions process. "Then additional information came in," he remembers, "pointing out that ammonia in the atmosphere neutralizes sulfuric acid, changing it over a sequence of events to ammonium bisulfate to ammonium sulfate. Health data indicate ammonium sulfate doesn't pose any serious health problems, but how far from the source will the sulfuric acid travel before being transformed?"

It is drama that goes on and on. Questions are answered with questions. Problems are solved, but solutions open upon new unknowns, new pollution problems. And those are solved. . . . That is how a North Carolina laboratory lights the way to a clearer view of what we've done, and to predictions of what we can do, to the air in and over our towns and cities. □

A Comeback For Culebra

By ROLAND D. PAINE

CULEBRA is its name. A small, sunny island not far from Puerto Rico, Culebra has until recently seemed to be of little importance. A few biologists knew of it as nesting site for two endangered species of sea turtles, the hawksbill and the leatherhead. Local mariners knew of it as the site of one of the most secure hurricane harbors in the Leeward Islands, Ensenada Honda. And several generations of U.S. Navymen knew of it because the Navy bombed, shelled, and strafed it for 40 years.

The noise of exploding ordnance is gone now. The natural sounds of calling seabirds and washing waves are joined only by the modest thrumming of business and household as the small population goes about its daily affairs, conducted in the melodious tongue of the *puertoriqueños*. The island's unique natural resources are protected. Plans are afoot to survey target areas to locate unexploded shells and bombs, and to post and patrol hazardous zones.

Culebra's newly-found importance lies in the fact that these protective and restorative measures are being undertaken under the east coast's first (and the Nation's second) approved coastal zone management plan. A Certificate of Approval for the Culebra Segment of Puerto Rico's coastal zone management plan was awarded to Governor Carlos Romero Barcelo of the Commonwealth by Robert W. Knecht, NOAA's Acting Associate Administrator for Coastal Zone Management, on April 15 in San Juan, P. R. A NOAA grant of $295,000 accompanied the certificate and permitted the Commonwealth to put the Culebra management plan into operation.

Culebra is about seven miles long and three and one-half miles wide, and lies approximately 17 miles east of Puerto Rico, 12 miles west of St. Thomas. Its total area, including surrounding keys, is 7,700 acres. Its topography is low and rolling, with the tallest hill being Monte Resaca at an elevation of 650 feet. The long and intricate shoreline consists of a series of bays, peninsulas, and bars, some of which end in abrupt cliffs, others in sandy shores or mangrove forests.

Culebra is also very dry. Mean annual rainfall is only 36 inches, and about half of this falls in the period August-November. Nor are there any permanent fresh water streams, so the supply of fresh water on the island is very limited. The population depends primarily upon drilled wells, cisterns, and a small desalinization plant. The lack of water is in large measure reponsible for the small size of the population and the limited development of the island.

The United States obtained Culebra, along with the rest of Puerto Rico, by the Treaty of Paris of Dec. 10, 1898, at the end of the Spanish-American war. The treaty also transferred title to Spanish Crown Lands (roughly one-third of the land of the island) to the United States Government.

President Theodore Roosevelt placed the Federal land on Culebra under the jurisdiction of the Navy on Dec. 17, 1901. The Navy maintained a large facility there from 1902 until 1911, returned briefly in 1914, and again in 1924. In 1936 the Navy once again returned to Culebra, this time to establish target ranges for ship and aircraft gunnery and bombing practice. These facilities remained in active use until 1975, when all active Navy operations ceased except for an electronic warfare monitoring station. The Navy's use of parts of the island for target practice had long been a source of tension between the Commonwealth and elements of the Federal government, particularly in the last decade.

Because of the value of the land and because of the controversy surrounding the target areas, members of the United States Congress became interested in the little island, and on June 16, 1971, the Senate Committee on Interior and Insular Affairs adopted a resolution requesting a study of Culebra and vicinity to determine the best uses of the island's natural resources, including identifying areas "that should be established as fish and wildlife refuges, scenic and recreation units, and development areas compatible with the natural environment of the island." Two years later the Secretary of the Interior and the Governor of Puerto Rico submitted to the Committee a joint report, "Culebra: A Plan for Conservation and Development," in response to the resolution. It was the first major step in realizing the dream of islanders and of ecologists to end the use of the island as a target and begin restoration, looking toward preservation of the island's natural qualities and limited economic development consistent with the capability of the island to absorb it.

The report concluded that the imminent departure of the Navy, and the anticipated transfer of extensive federal property holdings to Puerto Rico, would create "both a unique opportunity and a new responsibility, not only for Culebra's residents, but also for the enhancement and preservation of Culebra's remarkable natural and wildlife resources."

The NOAA funds to implement the coastal zone management program for Culebra are intended to help Puerto Rico respond to that opportunity. They were granted to support the management phase of the Culebra Segment, as it is called—just one part of Puerto Rico's overall coastal zone management plan, but a particularly significant part because it meets a pressing need.

The real beginnings of Puerto Rico's coastal zone management program go back to 1972, the year that the federal Coastal Zone Management Act was passed. In that same year, working quite independently, a group of interested citizens produced a report called "Puerto Rico and the Sea" that proposed an action program for marine affairs, a report submitted to the Governor. That landmark document identified the critical problems faced by the coastal zone of the Commonwealth, and provided general guidelines and recommendations for solving them.

The Department of Natural Resources of Puerto Rico built upon the knowledge and impetus provided by the group's publication, and worked with the Puerto Rico Planning Board and NOAA's Office of Coastal Zone Management to create an overall management program. Within the Department, part of the staff set to work on an overall coastal zone management plan, and established the Culebra Segment—a geographical, political, and resource unit whose urgent and special management needs were recognized.

Early on, in conjunction with Carol Sondheimer of OCZM, it was decided that planning for the Culebra Segment should go ahead rapidly, preceding the overall Puerto Rico management plan, so that the Commonwealth could put in place as quickly as possible an approved plan for restoring the battered little island.

As with all coastal zone management plans, devising the Culebra Segment involved taking into account the comments and suggestions of two groups that on the surface may appear to be widely divergent, but that in the crucible of open and democratic planning often turn out to have similar or complementary views. One group is composed of government agencies, working to carry out their legal responsibilities to the nation's citizens. The other group is the citizens themselves, expressing their needs and desires directly.

Comments of the federal agencies on the draft plan of the Culebra Segment added strength to the document in many ways. The Environmental Protection Agency, for example, raised helpful questions regarding solid waste and waste water disposal. The National Marine Fisheries Service noted its interest in preservation of endangered and threatened species of sea turtles. The Coast Guard wished to ensure that navigation aids would be adequately maintained and that marine pollution laws would be properly enforced. The Department of the Interior provided the planners with a list of working contacts from such groups as the Fish and Wildlife Service, the Bureau of Outdoor Recreation, and the U. S. Geological Survey, who could be helpful in many aspects of the plan. The Navy provided vitally necessary maps and charts.

Comments from the citizens of Culebra came from the vantage point of the people most directly concerned. Public hearings in June, 1976, elicited much of their helpful comment. Mayor Ramón Feliciano of Culebra pointed out that the Culebra Municipal Government had already prepared a development plan, and suggested greater emphasis on specific uses of certain coastal areas. A property owner provided information on alleged illegal uses of the land, which he felt ought to be recognized in the plan. Another resident expressed interest in the waste water treatment facilities planned. A commercial fisherman pointed out the relationships between the local fishing industry and the mangrove forests, asking for procedures that would answer the needs of the industry.

Plans for managing Culebra—owing to its small size, the entire island is encompassed within the coastal zone—will assist the natural as well as the man-made environment of the isle. Most of the ecosystems— and Culebra contains a surprisingly large variety—have been affected by the presence of man, but there exist the remnants of many original communities of plants and animals. Some of them are . . .

Hilly savannah, from grassland to sparse forest . . .

Hilly forests, from dry to moist . . .

Beaches . . .

Lagoons, just behind several of the beaches

NOAA Associate Administrator for Coastal Zone Management Robert W. Knecht and Puerto Rico Governor Carlos Romero Barcelo (center two figures) huddle during ceremony awarding Certificate of Approval to the Commonwealth for the Culebra segment of its coastal zone management plan.

A Visit to Culebra

CAROL SONDHEIMER of the Office of Coastal Zone Management visited Culebra while working with the Commonwealth of Puerto Rico on the Culebra Segment. Her impressions of the island were strong and lasting; upon returning to San Juan she jotted them down. The following is an excerpt.

Culebra—An almost unnatural stillness and quiet punctuated only by the breeze rustling through the trees (not palms, trees) and responsive crowing of roosters in yards along the route into town.

Culebra is reached either by air or by water. It is off the eastern end of Puerto Rico separated from the main island by a series of minuscule islands, rock outcroppings and coral reefs. St. Thomas, the Virgin Islands, is visible from the eastern portion of Culebra on a clear day. By ferry, the trip between Puerto Rico and Culebra takes three hours, if the waters are calm enough to permit the ferry to chance the crossing. By plane, it's less than an hour from San Juan.

The approach to Culebra by air is complicated by the necessity of having to go clear around the island and approaching it from the far (eastern) end when the Navy is engaged in bombing practice along the western peninsula of the island. Such is the case today and the approach is not an easy one. The wind is at the plane's tail and the airstrip is a short run at the mouth of the enclosed harbor, deadending into a small mountain. Two approaches are necessary before the landing can be successfully negotiated (and even then, with a lot of buffeting and bumping of the aircraft).

Once on the ground, the sense of stillness is paramount—the lack of intruding noises, the heaviness of the air, the lack of activity within the houses, the slowness with which the people move about.

Culebra is populated by approximately 1,000 people in two neighboring towns—Clark and Dewey—named, appropriately enough, for Navy admirals. In addition to the two towns, the only other major installations on the island are the naval surveillance facility on the northwest bluff of the island and the naval target range on the western peninsula. The Navy has excessed the target range and supposedly will vacate that property as of July 1, 1975. Whether they complete the actual physical move by that date or not, the mayor and townspeople of Culebra intend to hold a major celebration on that date, a sort of advance independence day celebration.

The only way to get into town from the airstrip is to walk—slowly, in the early morning heat. Past homes built on squatted land adjacent to the water, past an open air bleacher for watching baseball games, past the power plant which is across the street from the bandstand that is the focal point of the Club Nautico Culebra fishing competition held annually in January, past men sitting about on porches of small wooden houses, past the high school upon a hill and the elementary school lower on the slope, past the dispensary with the shiny, new ambulance parked out front. The Alcaldía—the City Hall—is located at the top of a small hill. It is painted a bright yellow-gold and the inside is in the process of renovation. The mayor is located on the second floor. His office, in the front of the building, has a panoramic view of the harbor and the bay on either side. There are no walls to the office yet. So the mayor's desk and the four chairs for his guests create an almost Pirandellian effect on this wall-less platform that represents an office.

Flamingo Beach is boasted about as one of the loveliest beaches in all of Puerto Rico. The sand has a finely bleached silkiness; the sky is a brilliant, cloudless blue, and the breeze has a refreshing coolness to it. Flamingo Beach, however, is a small parcel of shorefront surrounded on three sides by heavy steel fences. This is because Flamingo Beach is a piece carved out from the naval target practice range.

At first, one wonders how these people live and what they do for entertainment. Tourism is not a great mainstay of the economy. There's a small hotel in town and a few houses on the far side of the harbor that are rented by the week. There are occasional overnighters—folks sailing leisurely about the Caribbean. Some of the wealthier Puerto Ricans maintain second homes on Culebra and there is a small plastics casing industry on the island. There are people on this island, however, who have never seen a movie, a museum or even been off the island as far as San Juan. But there is television and there are several bars, and more than that there is the sun, surfing and fishing; there is the time to sit around with friends and the freedom not to worry about time and other barbarities of urbanized life. After a bit, one no longer wonders at how they live . . . one marvels. □

Mangrove swamps . . .

And coral reefs.

Plus, of course, the ecosystems that now include humankind as the dominant life—towns, harbors, and fishing grounds.

The tallest trees on the island are fan-leaved palms, some up to 50 feet in height, but they are fast disappearing because of human intervention, leaving only much smaller trees behind. Of the 372 species of plants, both native and introduced, three are found on Culebra and nowhere else in the world. Wild orchids abound in some areas.

Another striking life form is the bird population—sooty terns, brown boobies, laughing gulls, brown pelicans (an endangered species), Bahama pintails, and masked and ruddy ducks are among the many of interest to ornithologists. They share habitats not only with the two endangered species of turtles, but also with the loggerhead and green sea turtles, which have been proposed for "threatened" status.

Designation of protected wildlife areas has already begun, and is high on the priority list for the island's management.

Because of the limited space and uncertain water supply, the human population of Culebra is planned to be kept to a very low growth, up to 1,057 in 1980 (only about 67 more than the 1977 population) and no more than 1,221 a decade later. The little towns of Dewey and Clark are to be provided with sewer and water as part of the pollution control program, and the special problem of squatters—people who have established residences on public land—will be addressed through gradual removal, as alternative housing nearby can be made available for bonafide residents.

Air pollution is virtually non-existent on the island, but its peculiar pollution problem, that of the unexploded bombs and shells, will be addressed by locating and marking the areas. Eventually, it is hoped, ways can be found to remove or defuse the ammunition, so that additional acreage can be restored to safe use.

Records show that there are about 38 commercial fishermen on Culebra, working about 25 boats of 14 to 18 feet in length. Their most important catch is spiny lobster, although catches have declined in recent years. On the other hand, recent statistics by the Commonwealth agency Acción Comunal indicate a sharp increase in total fish catch, a trend that will be encouraged. The plan also envisions development of sportfishing resources around the island.

Culebra is its name. Snake, in English. The sunny little island has fangs of powder and steel, a lethal potential for the unwary. But now it also has the capability to be defanged. An approved coastal zone management program, a vigorous Commonwealth government to put the plan into practice, and the support of NOAA's Office of Coastal Zone Management will ensure that the natural resources of Culebra—the plants and birds, the turtles and fish, the beaches and forests—can undergo restoration and replenishment. And most important, the people of Culebra can expect to see a steady enhancement and enrichment of their lives. □

Restoring Tide Stations

By JOHN G. STRINGER

BILL DONOVAN sat facing a U-shaped console of closed-circuit television monitors and radar displays in the Cape Cod Canal traffic control center. He glanced up from the console and looked out the uninterrupted runs of tinted glass on three sides of the room. It was an early spring morning—bright, windy and cold—with white, swirling rivulets of powdered snow blowing across the ground and into the canal. There was no traffic. He leaned back and lit a cigarette.

"It was the worst ice pile-up since the winter of 1933–34," said Donavan who was in his 49th year as a traffic controller. "A 300-foot sheet of ice more than four feet thick cleaned out more than 16 dolphins, a 40-foot pier at the east end, and destroyed the tide gage house."

For a few moments Donovan watched five Canadian geese that were poking their beaks under small clumps of frozen turf on the windless side of the Center. "The canal had to be closed for three weeks," he continued. "The only other time the canal was closed before was when a coal carrier hit the block and sank near the Bourne Bridge."

Beyond the geese, two sea gulls hovered near shore, suspended above the water against the wind. Only their heads were moving, from side to side. "That's Bonnie and Clyde," he said. "They're still looking for the pilings they fought continuously over last summer—sheared right off at the mud line."

The destruction to piers and pilings on the Cape Cod Canal by the Nation's coldest winter in decades also had an equally severe effect on at least half of the National Oceanic and Atmospheric Administration's primary tide observation stations in the northeastern United States. Strategically dispersed throughout coastal and oceanic waterways, NOAA's network of tide stations are a source of tidal knowledge that is indispensable in determining issues ranging from safe navigation to construction of offshore facilities.

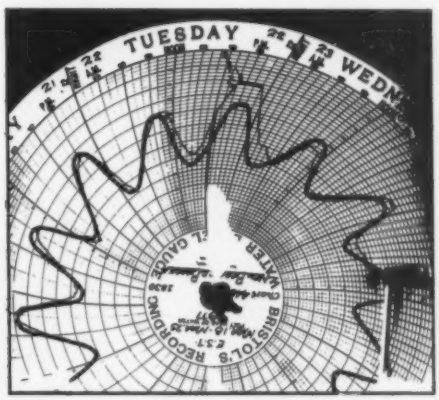
NOAA's National Ocean Survey began a systematic collection of tide data in 1844 to support mapping and charting effort. This information was necessary for the determination of the mean high water datum for delineating the shoreline and the mean low water datum for a common reference of the depth soundings on nautical charts.

To provide the capability to determine these datums, the National Ocean Survey today maintains a network of some 130 primary control tide stations which constitute the National Tide Observation Network. These stations provide the long-term records covering the full 19-year Metonic cycle required for determination of tidal datums. It is through these stations that tidal datums may be computed from shorter period of records and reduced to the equivalent of 19-year mean values.

In addition to supporting hydrographic surveys and making tide predictions, one of the largest demands for tidal observations is in the area of coastal zone management where the legal aspects of coastal property boundaries involve the location of local tidal datum lines. These marine boundary determinations establish ownership and control of valuable coastline property and submerged resources.

Anticipating the increasing need for these determinations, the National Ocean Survey's Office of Marine Surveys and Maps has initiated a comprehensive effort to obtain the data required to establish the marine boundaries of the United States involving nearly 90,000 miles of shoreline in 27 coastal states and island possessions. The estimated cost for the program is $40 million and the time involved, governed by available resources, could run from 20 to 30 years. Within this plan the NOS tide station plays a most significant role.

The basic information for tidal datums is gathered by the Oceanographic Division's Tides and Water Levels Branch from the measuring tide station, which is classified either as primary, secondary, or tertiary. The station, often called a "shack" by its observer, or tide-watcher, houses equipment to take the temperature of the water, to measure the tides and to record each variation as an aid to mariners. This is done by a float which rides up and down on the surface of the water, as the tides rise and fall. The float, which isn't affected by wave action because it sits shielded inside a circular well, operates the analog-to-digital recorder tide gage inside the station. Using a dry cell battery to convert the motion of the rotating float-wheel shaft into a coded punched-tape record, the water level is recorded at selected intervals. The observer, who can either interpret the code visually or have it machine processed by a



Controller Bill Donovan (left) keeps a watchful eye over canal traffic while the New Bedford Hurricane Barrier tide gage (above) warns that an excessively high tide is imminent. As indicated by the flat trace, the barrier was closed at 8 p.m.

Far left: Jill Meldon, Jim Dixon and Al Landsbergis inspect remains of Buzzards Bay (Mass.) pier. Because of the severe winter damage to their tide stations, observers Madge Kaskela (left) and Fred Wiley (above) will get new stations.

special translating device, must check the gage at least five times a week.

The winter of '77 caused many tide gage malfunctions such as floats freezing in the float wells which resulted in wire breakage and tangles. Of a more serious nature, however, was the damage of the ice on the fixed tide staffs to which all tidal datums are referenced. To evaluate damage to the tide stations from North Carolina to Maine, a special reconnaissance team headed by James Dixon of the Requirements & Facilities Section, left NOS headquarters in Rockville, Md., on March 24. Accompanying Dixon were Al Landsbergis and Jill Meldon.

Driving during most of the night through gale-force winds and freezing rain, the team arrived in Boston where it would continue its inspection from Cape Cod to Rockland, Maine.

The following morning, the team drove to Boston's Fort Point Channel. The rain, intermittently mixed with snow, resolutely fell. From outward appearances, the Boston tide station looked as if it had survived the winter. But on closer examination, the team discovered that the station's foundation had been substantially damaged by ice and frost heave. Even steel braces that held the float well to the piling had been destroyed, and the tide measuring device was out of plumb.

While the team set up surveying equipment to confirm its observations, Fred W. Wiley, the station's observer, came to make accuracy checks and to take readings of temperature and tide. Wiley, who receives $50 a month, has been a tide observer since 1972 when he retired from the National Weather Service.

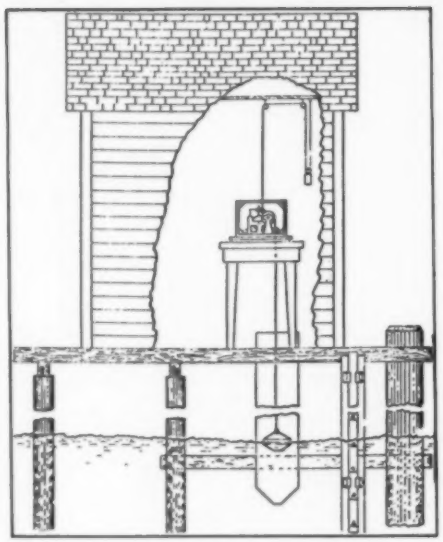
"That's not all I watch," he said as he checked the damaged float system. "Until the winos moved to the combat zone up on Stewart Street, this pier was their meeting place. I've had only one break-in, though. And that was years ago."

Wiley is part of a small army of tide observers who visit their stations daily and report on tide height, salinity, and the temperature of the water and air to NOS headquarters in Rockville, Md.

"Last year, I missed one day because of the snow and ice," said Wiley, who lives in Avon, about 19 miles from the station.

The reconnaissance team later recommended that Wiley's tide station be replaced, and if possible moved to the nearby New England Aquarium. Wiley will still be its tide observer, and will maintain the station's new equipment which will include both a digital and analog gage which draws the actual tide curve. Plans also call for the station's tide recorder to telemeter water levels to the National Weather Service at Logan International Airport, providing information to aid in warning Boston's metropolitan area of rising water levels from winds or heavy rains.

The tide station at Sandwich, Mass., stands alone on the U.S. Army Corps of Engineer's patrol dock. It is under the daily surveillance of Madge Kaskela who recently had to replace its lock because "everybody from hell to breakfast had a key," and was using the station for fishing and drinking beer.



Schematic view of installation of standard automatic tide gage.

Mrs. Kaskela has been a tide observer for six years, a job she thought would end abruptly one day last winter when the ice, "smacking up under the floor," nearly destroyed the station.

"We're going to take a ride today," she thought when she called the Corps for assistance. Together, they tied a hawser around the shack, securing it to a cement post.

"The ice took the pulpit which connected the tide house to the tide staff," she said. "And the pile foundations were destroyed."

For a comparison, Mrs. Kaskela believes that the storm in 1933–34 was far worse than the one last winter. "All those who survived that," she said, "got married the next year."

Mrs. Kaskela is a "canaler." Her husband has spent 25 years on the canal, and her father, one of the original pilots on the Cape Cod Canal, formed the first pilot association. Besides her job as a tide observer, she runs a rooming house, and opens sea scallops which she says are a "tremendous bonanza off the back side of Buzzards Bay here."

Mrs. Kaskela also delivers telephone books, and is a newspaper reporter. "I got an oar into everything that goes by," she said. Between all of these activities, she finds time to visit Florida every year—ferrying someone else's automobile. During this brief absence from her beloved canal, she has trained a young Navy veteran "to do the stuff" at the tide station.

In spite of its appearance of solidity, Mrs. Kaskela's tide station must be completely rebuilt. It has also been recommended that the station be relocated elsewhere on the canal.

Bill Donovan was pointing to where the Cape Cod tide station had been located when Frank Morris entered the control Center. Dixon, who had met both Donovan and Morris during a previous visit to the U.S. Army Corps of Engineer's facility, introduced Morris to his reconnaissance team.

"The ice formed in Buzzards Bay, at the west end of the canal," said Morris, who is a control center engineer. "The current, which is about four knots, moved the ice in sheets 300- to 400-feet long through the canal. It completely destroyed the pier on which the tide station had been built."

Morris went over to the Bristol transmitting gage system which is the canal's link to the Bedford Hurricane Barrier tide gage. Pointing to the heavy line indicating NOAA's predicted tide levels for New Bedford, he said that the computer printouts supplied by NOAA to the Corps and the comparison of these lines "allows us to predict the tide surge, which yesterday—because of the rain and snow—was 4 feet 6 inches. With this information, and the fact that there were winds up to 68 knots, we closed the barrier gates and cut the top of the tide off to maintain the water level inside the harbor. This action saved at least $75,000 in possible flood damage." He said that the data also can be used to decide whether a large vessel will get the green light to enter the canal.

Leaving the Center to inspect the tide house and pier damage, Morris mentioned that the Sandwich Police Department had just found "a new type of fish in the canal."

"What was its specie?" asked a member of the NOS team.

"Silver Cordoba," said Morris. "With barnacles."

The ice had completely destroyed the huge support pilings at the end of the pier, cutting them off at the mud line, leaving only a few feet of catwalk dangling above. Before the destruction of the pier, the Corps had removed the tide station to shore and safety. In its recommendation, the team requested that the building's location be changed to a site in Buzzards Bay. The move would provide better control for the entire Bay area where tide measurements and its characteristics would not be as limited as on the canal.

In the detailed damage and impact assessment prepared by Dixon's team of the 42 primary and eight subordinate stations checked in the northeastern coastal states, 14 stations were completely destroyed and require immediate reconstruction. Nineteen of the remaining stations were damaged or weakened and require refurbishment or repair to station components such as building, foundations, float wells, and tide staffs.

Emergency repair operations and verification leveling by NOS personnel was initiated immediately and is continuing until completion. The cost for the reconstruction and to restore the operation of the National Tide Observation Network is estimated at $374,000.

In his assessment report, Dixon said "the impact of damage to NOS tide stations due to the severe winter of 1977 has been catastrophic." The damage, if not repaired, would result in a loss of vital data required for accurate determination of tidal datums used by Federal and state agencies and private industry.

With emergency funding requested, NOS is working to return the damaged stations to service and ensure stability of tidal datums. □

Tips From The Pros

What can individual Americans do to help the nation save energy?

Plenty. To begin with, their automobiles burn 14 percent of all energy consumed in the U.S each year, and the heating and cooling of their homes accounts for an additional 11 percent. There is room for enormous savings of fuel—not to mention money—in both areas. But there are also scores of other ways for consumers to conserve, some of them surprising. Not many people know, for instance, that their hot-water heaters gulp more energy than their air conditioners, refrigerators, color-television sets and freezers combined. Or that the pilot light on a gas range accounts for up to 50 percent of the gas used by the appliance and should be replaced with electric igniters.

Experts also say that people who use dishwashers consume less energy than those who wash by hand and run hot water to rinse the dishes. But, they point out, those who stoke up their fireplaces thinking they are saving on gas or fuel oil are wrong: most fireplaces actually suck more heat out of the house and up the chimney than they radiate.

The most conspicuous energy consumption is done by the family car, and no conservation policy is likely to prove worthwhile unless it persuades people to drive less. Car pools represent a big opportunity. Commuter cars today carry an average of only 1.3 persons apiece, and the Federal Energy Administration says that if just one more passenger climbed into each car for each trip, enough gasoline would be saved daily to power 67,000 cars traveling from San Francisco to New York and back again. What's more, if each car owner could eliminate one short trip a week—to the supermarket, for example—the nation's gasoline bill could be cut by 7 percent.

There are as many other energy-saving tips around for drivers as there are options on a new sports car. By observing the 55-mile-per-hour speed limit rather than driving at 70 mph, for instance, motorists will cut their gasoline use by 21 percent. Drivers should also accelerate slowly, saving not only fuel but engine and

DON't wash the dishes by hand

tire wear. And they should check their tire pressu e often: underinflated tires lead to the use of more gas.

Cold Comfort: Cutting the energy load required to heat the nation's homes requires two things: more insulation and a willingness to give up a little confort. More than half of all U.S. homes are either improperly insulated or not insulated at all. Adding 6 inches of insulation on the attic floor and buying storm windows would probably cost hundreds of dollars, but the investment returns dividends in lower heating bills—and ends up paying for itself in a few years.

Homeowners can reduce their heating costs 15 to 20 percent simply by turning down their thermostats 6 degrees Fahrenheit—the amount President Carter suggested last winter. If the temperature in every home were cut by that much, enough fuel would be saved each winter to heat 9 million homes. For about $50, homeowners can buy clock thermostats that automatically turn down the heat at night and turn it back up again in the morning.

DO break out the manual lawnmower

For those who find chilly houses uncomfortable the FEA suggests that warm clothing is "the best insulation of all." Madelyn Lefkowitz of Cleveland Heights, Ohio, says her family reaped a huge fringe benefit by shutting off the heat to bedrooms and forcing everyone to congregate in the family room. "Family relations were never better," she says. "We had more opportunity to communicate and do things together." Consumers can also save themselves money this summer by turning their air-conditioner thermostats up; keeping the house at 78 degrees F. instead of 72 can cut cooling costs by 47 percent.

Gulper: The consumer's next biggest energy gulper is the hot-water heater—it accounts for 15 percent of the fuel used in the home. The temperature of a heater is usually set at about 150 degrees, but people who drop that to 120 degrees will find their water still hot and their fuel bills down 9 percent. Most households can also do with a lot less hot water. Warm or cold water can do most loads of laundry nicely, and showers use only about half as much hot water as tub baths. Letting the hot water run while shaving is an obvious waste, and wet-shaving itself isn't efficient. Val Finlayson, engineer with the Utah Power & Light Co., maintains he can use an electric shaver for two full years on less energy than it takes for two or three wet shaves with the water running.

There are myriad other ways for individuals to conserve, and they could add up to a big savings. Lighting experts point out, for example, that even though they are initially more expensive, fluorescent bulbs are cheaper to operate than normal incandescent bulbs and they last up to ten times as long. Where lighting isn't a safety factor, removing one bulb from a three-socket fixture and substituting lower-wattage bulbs for the other two can cut electricity use appreciably. And switching off unneeded lights may be the best saver of all.

Each household appliance offers conservation opportunities of its own. Ovens seldom need to be preheated, despite what the recipes say, and they can be turned off about ten minutes before the food is done—the residual heat will finish the job, and save the household chef money. Frost-free refrigerators save a lot of work, but they are also prime energy wasters. Dishwashers should be run only when full. They also should be turned off when the final wash cycle is completed and the door should be opened, letting the dishes air-dry. Refrigerators and freezers should be kept as full as possible—food retains cold better than air, reducing the load on the equipment.

Free Advice: To help drive conservation home, more and more utilities around the country are giving their customers free advice and "energy audits" on how to use their appliances more efficiently. And the FEA urges people to begin thinking in terms of life-cycle costs rather than price tags when they buy

DON'T light up the fireplace

appliances. A cheap room air conditioner may cost less than one with a high "energy-efficiency" rating, but over the life of the unit, fuel savings from the more efficient machine will more than offset the price differential. Consumers who want to press conservation still further can make sure that the blades on their power lawn mowers are sharp—dull edges mean that the motors have to run harder. Better yet, hand mowers consume nothing more than people power.

President Carter's energy program will be followed by official exhortations to save fuel in ways such as this, and the question is whether or not American consumers will pay any attention. Thus far, they haven't been listening very carefully. But the cost of energy is bound to rise as a result of the President's plan—and perhaps more than any patriotic calls to conserve, higher fuel prices may prove to a nation of energy squanderers the virtue of frugality. □

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A WESTERN-RIGGED New England trawler steams steadily through the dark, July-warm waters of the North Atlantic 180 miles due south of Rhode Island. It is 5:30 in the morning and outside the first hints of the new day loom grey on the horizon. Inside, the monotonous throb of the engine, a GM 8–71, is broken occasionally by a high-pitched whine from the auto pilot's electric motor under the instrument panel. The only light comes from the instrument panel itself and a tiny bulb illuminating the compass.

Alone in the wheelhouse, the captain of the vessel is searching for a bright orange plastic buoy marking a half-mile long trawl line of lobster pots lying under 150 fathoms of water. The buoy is large, about three feet in diameter, and it is topped by a tall pole bearing a radar reflector. But compared to the area of the Atlantic fishing grounds, it is smaller than a ping-pong ball in the middle of a 10,000 acre Kansas wheat field.

The captain glances back at a small grey box which is silently displaying electric-green numbers on a tiny panel. He makes a slight course correction to the east, flips on his radar, and in less than seven minutes is alongside the buoy. He and his four-man crew are about to begin a long, hard day of lobstering.

Navigation has come a long way since the time when sailors had to rely on sextant and compass, chronometer and astronomical tables, all of which were subject to built-in inaccuracies or human error or both. And in bad weather, with a cloud cover that might prevent a ship's getting a fix for a week or more, all a master could do was depend on careful guesswork and a lot of luck.

The notion of anchoring a three-foot floating sphere to the bottom of the ocean, almost 200 miles from shore, and then returning five or ten days later to pick it up would have struck even the most competent and far-sighted navigator of 100 years ago as utter nonsense.

Since World War II, however, remarkable progress has been made in the field of navigation, particularly through the use of radio transmissions from shore. One of the most important advancements, both to commercial and military craft, has been through a system called Loran-A (for LOng RAnge Navigation).

Called a hyperbolic system, because the transmitted radio signals define hyperbolic lines of position on a chart, Loran-A works this way: a land-based Loran station (called a master) transmits a series of continuous pulses of known frequency, in the 1850 to 1950 kiloHertz (kHz) range. A second transmitter (called a slave or secondary station) some 200 to 300 miles away beams an identical signal—same pulse rate and same frequency. Because the two transmitting stations are separated geographically, unless a vessel is exactly equidistant from the two stations, the signal from the closer station will be received a few microseconds—millionth of a second—before that from the more distant station. Onboard a vessel—our New England lobster boat, for example—a Loran receiver picks up these signals, calculates the delay in microseconds, and displays a number showing the delay. There is one further refine-

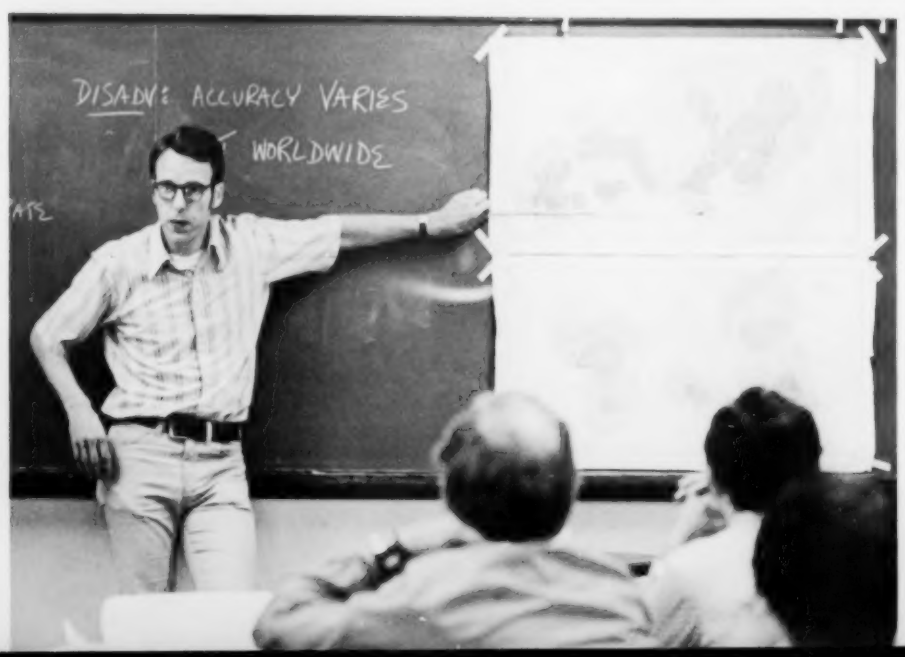
Photo: U.S. Coast Guard

LORAN

A to C

Sea Grant helps in the quest for pinpoint navigation

By BRIAN E. GORMAN



The Coast Guard's secondary Loran-C transmission station for the west coast, located in Middletown, California (above). At left, Oregon State University's Dr. Daniel Panshin conducts a class for commercial fishermen on the forthcoming switchover from Loran-A to Loran-C.

ment. You may recall from Mrs. O'Connor's algebra class that a hyperbola has both positive and negative values. In order to insure that only positive values are received, the secondary station delays its transmission by a predetermined time factor, generally 1000 microseconds.

It is only necessary for the value of the delay to be compared with a series of numbered Loran curves printed on a nautical chart for a skipper to know that his vessel lies somewhere along a particular hyperbolic curve. A second reading from another pair of Loran stations, gives a second, intersecting curve and therefore a fix.

Loran has a number of advantages, not the least of which is the fact that it isn't necessary to understand any of the foregoing explanation to determine where you are. It has a considerable range, from 500 to 700 miles during the day. And it's remarkably accurate, with an absolute accuracy of one-half to two nautical miles and a repeatable accuracy—that is, the ability to consistently return to the same spot time and time again—of 500 to 1500 feet. Furthermore, unlike the system of celestial navigation that had been used for centuries, Loran-A is not seriously affected by bad weather and can be used day or night.

In spite of what would seem to be an almost ideal system for offshore navigation, the Department of Transportation through the U.S. Coast Guard, which maintains all U.S. Loran transmitting stations, decided in the early 1970's to take a hard look at the navigational requirements of vessels in the coastal confluence region, that is, the area from the coast out to the 100 fathom curve or 50 nautical miles, whichever is greater.

And it discovered some serious problems. Loran-A transmitting stations, many of which had been in operation since the 1940's, needed upgrading at considerable capital expense. Moreover, some sections of the coast had "dead spots" close to shore where, because of the location of transmitting stations, there was poor Loran coverage. Finally, there was the question of accuracy. With increasing merchant traffic, much of it involving oil tankers, an absolute accuracy of even one or two miles might not be enough. For commercial fishermen, who frequently need to know exactly where they are, either to pick up crab or lobster pots or to avoid tearing up their nets on known underwater obstructions, a repeatable accuracy of 100 to 1500 feet could prove insufficient.

As a result, on May 16, 1974, the Department of Transportation published its plans in the Federal Register to implement a new, more efficient, and more accurate system of long range navigation: Loran-C.

Loran-C, which has been in operation on the U.S. east coast since 1958 and the Mediterranean Sea since 1959, works in much the same way as Loran-A, although the transmissions are at a much lower frequency, 100 kHz. It has a number of clear-cut advantages, however. Its range is far greater, up to 1500 miles during the day. It requires fewer transmitting stations and fewer operators at each station, lowering both capital and labor costs. And its ability to tell someone where he is is almost uncanny, with an absolute accuracy of one-tenth to one-half a nautical mile and a repeatable accuracy of 50 to 500 feet!

The Coast Guard soon discovered, however, that implementing a new system of navigation would present more than mere technological hurdles. True, a network of Loran-C transmitting stations had to be built and engineers had to be put to work to insure that the electronics involved would be reliable, economical to run, and protected against obsolescence over the next decade or two. But the Coast Guard's greater challenge turned out to involve not its own transmitting hardware but the users themselves.

The present users of Loran-A, those who would be most affected by the Loran switch, as might be expected, number in the tens of thousands, on both coasts, in the Gulf of Mexico, and in Hawaii and Alaska. They include commercial fishermen, pleasure and sport boat operators, charter and party boat skippers, the merchant marine, tug and tow boat companies, and a growing number of vessels that service the offshore petroleum industry.

"It became apparent," said one Coast Guard official "that to do this job right we were going to need the help of an organization that already had close contact with all of these users."

Enter the Sea Grant Marine Advisory Services.

In the spring of 1976, Dr. Daniel Panshin, associate professor of oceanography at Oregon State University, received a call from the Coast Guard, asking for assistance. As it turned out, OSU's advisory program had already been involved in Loran-C since the summer of 1974, answering questions from local fishermen and others about when the new system would be installed, what new receiving equipment would be needed, and what the costs to private users affected by the Loran-A/Loran-C switchover would be.

"With the support of the Coast Guard and Sea Grant's network of advisory agents, we could begin a full-scale effort to determine what problems users might have," Panshin recalls. By July, he and Dr. Charles Vars, Jr., associate professor of economics at Oregon State, had submitted a proposal to the National Sea Grant office in Washington to "determine the impact upon United States civilian marine Loran-A users of the presently planned schedule for expansion of Loran-C service and termination of Loran-A service."

The project, administered through the National Sea Grant Program and funded with $91,800 in Coast Guard money, promised to be far more definitive than that rather formal phrase in the proposal suggested. Among the problems that Panshin and Vars, with the Coast Guard's help, hoped to resolve were possible loss of investment in Loran-A receivers due to forced early retirement to otherwise usable equipment; the present high cost of fully-automatic Loran-C receivers (about $3000 to $6000) as compared to simpler, manual Loran-A receivers (about $750 to $1000), and concern as to the adequacy of supply and service; need for sufficient time for fishermen to convert "hang data"—information on underwater obstructions that might foul nets—on desired fishing areas from Loran-A to Loran-C coordinates; need for timely publication by NOAA's National Ocean Survey of Loran-C charts; and the general lack of information on Loran-C capabilities and characteristics and on the reasons for the transition from Loran-A to Loran-C.

"Nobody said it was going to be easy," said Panshin in a recent interview, "but I don't think anyone, not the Coast Guard, not the Marine Advisory Service, thought that so many people, so many government agencies, so many meetings, and so much legwork would be involved."

One example of the complexity of the conversion from Loran-A to Loran-C has to do with what would seem to be the relatively straightforward task of setting up a schedule for implementing the new service. The Department of Transportation published its original schedule for Loran-C implementation in the Annex to the National Plan for Navigation in July 1974. At that time, the Coast Guard planned to start up its Gulf of Alaska service on December 31, 1976, and, in the process, to change the configuration of the existing North Pacific Loran-C chain.

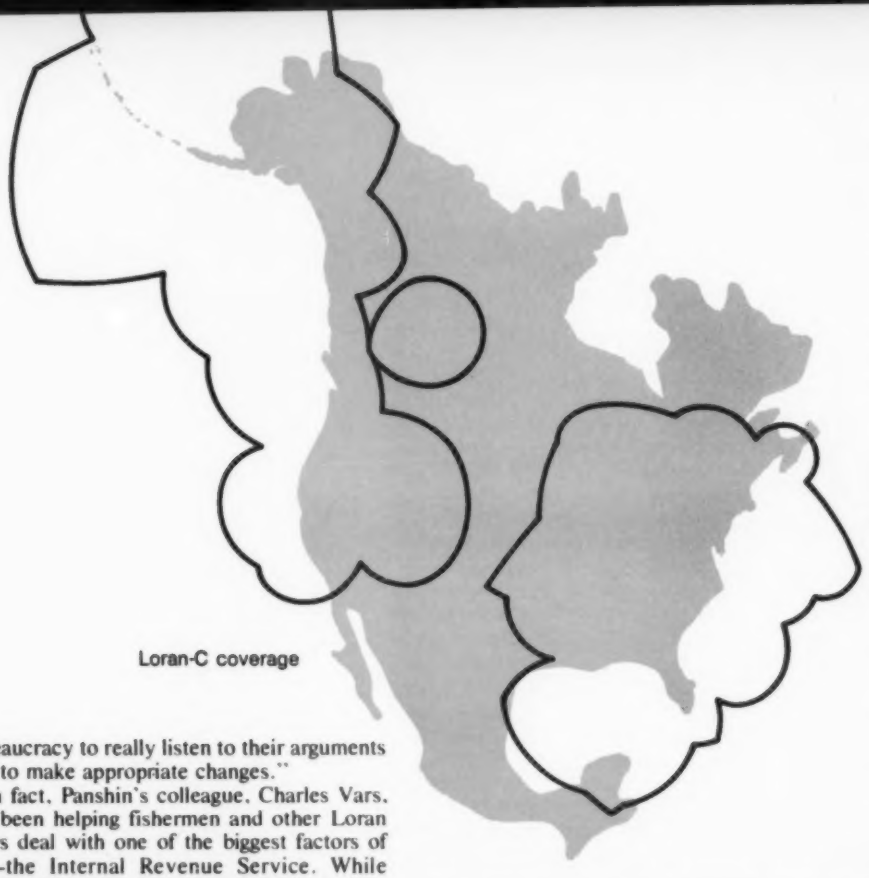
"From a technical standpoint, that was fine," said Panshin. "The transmitters and personnel to run them would all be ready. It looked as if it was just a matter of throwing a switch and sending out the new radio signals. Trouble was, the planned switchover was going to come smack in the middle of the Alaska king crab season. And no overlap period, when you'd have both the existing and modified Loran-C systems operating, was planned."

As a result of marine advisory service work with Alaska's fishermen and with the full cooperation of the Coast Guard, a more agreeable date was scheduled, June 1977. "It's to the credit of the Coast Guard," Panshin asserts, "that it was willing to change its plans."

In fact, changes of plans have almost become more the rule than the exception, according to Panshin. The National Ocean Survey, for example, charged with the sizeable task of reprinting its charts—some 85 in all—to incorporate the new Loran-C lines, had originally planned to produce charts with Loran-A markings on one side and the new Loran-C lines on the other. Unfortunately, for many commercial fishermen operating out of relatively small vessels without large chart tables, flipping over charts to transfer their Loran-A "hang data" and other information could have been a major inconvenience and might have increased the possibilities of error.

As a result of a Loran-C conference in Portland, Oregon, sponsored by the Coast Guard and Oregon State University's marine advisory service, NOS agreed that whenever practical it would print its charts with Loran-A and Loran-C lines on the same side.

"It may seem like a small point," says Panshin, "but it has helped convince the fishermen of two things: the usefulness of the marine advisory service as a neutral 'third party,' and, perhaps more importantly, the willingness of a seemingly faceless Federal



Loran-C coverage

bureaucracy to really listen to their arguments and to make appropriate changes."

In fact, Panshin's colleague, Charles Vars, has been helping fishermen and other Loran users deal with one of the biggest factors of all—the Internal Revenue Service. While Panshin has been out in the field, interviewing fishermen, talking to other marine advisory agents across the country, and generally trying to find who the users of Loran-C are, Charlie Vars has been back at his office in Corvallis, Oregon, trying to determine the cost versus the benefits of the Loran changeover.

One of the costs would be the necessary scrapping of otherwise usable Loran-A receiving equipment once Loran-A transmissions were terminated. With more than 50,000 users, that could represent several million dollars. A simple continuation of all Loran-A service to U.S. coastal waters beyond scheduled termination dates would not be the answer. Such a continuation would cost the taxpayers several million dollars per year. One possible solution is the use of special IRS depreciation schedules which would allow a fisherman to depreciate the cost of his receiving equipment more rapidly than normal or in some cases to declare an abandonment loss. Such tax savings would help make up for substantial losses and still allow the Coast Guard to stay on schedule.

Other costs and benefits may not be so easy to come by, according to Vars. What, for example, will be the cost of a new Loran-C receiver once manufacturers go into assembly line production? Right now, some Loran-C receivers are running as much as $6000. For those who can afford it and who want Loran-C's accuracy right away, that price may not be too high, but for the average fisherman, a wait of a year, according to Vars, may allow him to pick up a new Loran-C receiver for a much lower price.

"Another thing fishermen voiced concern about," reports Panshin, "was whether or not manufacturers would be able to gear up for the new production of Loran-C receivers. There was even some talk of a black market developing in the event of a shortage of sets." After contacting every U.S. manufacturer of Loran equipment, Panshin has been able to tell fishermen not to worry on that score at least. There will be enough sets to go around. And, according to manufacturers, the costs should continue to come down over the next year or so.

And so the research project continues. Since the beginning of the year, Panshin and his colleagues have begun a survey of recreational boaters to determine their potential use of Loran-C; mailed questionnaries to members of the offshore petroleum service industry; completed surveys of both the merchant marine and tugboat industries; continued field interviews with commercial fishermen; and made enough visits across the United States to support a small travel agency.

"The number of different agencies, manufacturers, headquarters, and field stations we have visited," contends Panshin, "is an indication of the enormous scope of the project." The list includes Coast Guard District Headquarters in Boston, New York, New Orleans, San Francisco, Seattle, and Juneau; the Coast Guard Electronics Engineering Center in Wildwood, New Jersey; Loran manufacturers and distributors in California, Oregon, South Carolina, Florida, Massachusetts, and Maryland; Defense Mapping Agency Hydrographic Center in Suitland, Maryland; NOAA components representing National Marine Fisheries Service, National Ocean Survey, and National Sea Grant Program; local marine advisory offices in every coastal state in the Union except Hawaii; and field interviews in a myriad of ports from Newport, Oregon, to Newport, Rhode Island.

There have already been two important results of this almost frenetic activity. First has been the realization by a number of disparate groups—fishermen, the Coast Guard, Loran equipment manufacturers, tow boat operators—that any changes in Loran that affect one group will, at least peripherally, affect them all. The second result, more tenuous but just as important, has been what Panshin calls the exemplary cooperation between the Coast Guard and the marine advisory service and among members of local advisory staffs themselves.

"Without the Coast Guard," says Panshin, "we clearly couldn't have any Loran system, new or old. Their technical expertise is essential. But without Sea Grant, with its nationwide network of agents, its contacts with industry, universities, and users, the Coast Guard's job would have been monumental. What's been most satisfying about our relationship with the Coast Guard is the *nature* of the cooperation. It grew out of a common perception of a national need, without any formal, bureaucratic 'Directives' or 'Memoranda of Understanding.' The Coast Guard knew they needed us, and the advisory service knew we needed them. And here we are, tackling this matter. Together."

There also has been "tremendous cooperation" with other Sea Grant marine advisory programs, according to Panshin. "I've been able to travel to coastal communities all across the country," he reports, "talking to fishermen and other users, helping present meetings, asking questions (and occasionally answering them), because we have a strong network of advisory agents out in the field pulling things together. I think it shows a maturing of the Sea Grant program. There really is a Sea Grant network out there."

The job is far from over, however. There is much that still has to be done in creating user awareness, although the Coast Guard is now embarking on a program to inform users more thoroughly about Loran-C. In fact, Loran-A transmissions aren't scheduled for termination on the east coast and in the Gulf of Mexico until the middle of 1980, and work will continue at least until that time.

But for Dan Panshin and Charlie Vars and for their counterparts in the Coast Guard, the real test—the ability to meet the challenge of instituting a new system of navigation and turning off an old one—is in the process of being met.

"In the marine advisory service we so frequently get involved after the crisis appears," Panshin said after a recent transcontinental journey to Delaware. "But with this Loran work, we've been able to get involved before the last chapter is written. We have a chance to help determine what the policies will be."

Off the United States west coast, on April 25, 1977, at 4 p.m. Pacific Daylight time, the first official transmission of the Coast Guard's west coast Loran-C system took place from a chain of transmitters in Nevada, California, and Washington. Pacific sailors may not know it, but that special transmission went a lot more smoothly because of the work done by the U.S. Coast Guard and the Sea Grant Advisory Service. □

Sea Fare

over the COALS

The National Fishery Education Center has published a new cookbook *Fish and Shellfish Over the Coals.* It can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The cost is 85 cents (GPO Stock Number 003-020-00052-5).

Easy-Do Fish Chowder

1 package (1 pound) cod or other thick fish fillets, fresh or frozen
1 cup chopped onion
2 tablespoons margarine or cooking oil
2 cans (10¾ ounce each) condensed cream of potato or celery soup
2 cups diluted evaporated or whole milk
1 can (1 pound) tomato wedges
1 can (1 pound) mixed vegetables, drained*
1 can (8 ounces) whole kernel corn, drained
1 teaspoon salt
⅛ teaspoon pepper
1 small bay leaf

Thaw frozen fish; cut into chunks. Cook onion in margarine or cooking oil until tender, but not brown. Add soup, tomato wedges, mixed vegetables, corn, salt, pepper, and bay leaf; heat, stirring occasionally, until simmering. Add fish; simmer until fish flakes easily when tested with a fork, about 10 minutes. Serve with crisp green salad and crusty bread or rolls. Makes 9 cups chowder.

*1 package (10 ounce) frozen mixed vegetables, thawed, may be substituted for canned, if desired.

Shrimp Kabobs

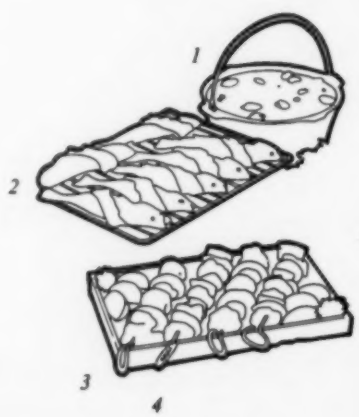
1½ pounds peeled, deveined, uncooked shrimp
1 can (13½ ounce) pineapple chunks, drained
1 can (4 ounce) button mushrooms, drained
1 green pepper, cut into 1-inch squares
¼ cup chopped parsley
¼ cup soy sauce
½ teaspoon salt
12 slices bacon

Thaw frozen shrimp. Place shrimp, pineapple, mushrooms, and green pepper in a bowl. Combine oil, lemon juice, parsley, soy sauce, salt, and pepper; mix. Pour sauce over shrimp mixture and let stand for 30 minutes, stirring occasionally. Fry bacon until cooked but not crisp. Cut each slice in half. Using long skewers, alternate shrimp, pineapple, mushrooms, green pepper, and bacon until skewers are filled. Place kabobs in well-greased wire grills. Cook about 4 inches from moderately hot coals for 5 minutes. Baste with sauce. Turn and cook for 5 to 7 minutes longer or until bacon is crisp. Makes 6 servings.

Ocean Perch Kabobs

2 pounds ocean perch or other small fish fillets, fresh or frozen
2/3 cup Italian dressing
3 small, firm tomatoes
1 package (10 ounce) frozen Brussel sprouts, defrosted
or
1 can (1 pound) whole potatoes, drained
½ teaspoon salt
Dash pepper

Thaw frozen fillets. Skin fillets and cut into strips approximately 1-inch wide and 4 inches long. Place fish in shallow baking dish. Pour 1/3 cup of dressing over fish and refrigerate 30 minutes. Wash tomatoes; remove stems and cut into sixths. Remove fish strips from dressing; reserve dressing for basting. Roll fillets up and place on skewers alternately with tomatoes and Brussel sprouts or potatoes, until skewers are filled. Place kabobs in well-greased, hinged wire grills. Add salt and pepper to remaining dressing. Cook about 4 inches from moderately hot coals for 4 to 6 minutes. Baste with sauce. Turn hinged grill and cook about 4 minutes longer or until fish flakes easily when tested with a fork. Makes 6 servings.



1. Easy-Do Fish Chowder
2. Fisherman's Delight
3. Ocean Perch Kabobs
4. Shrimp Kabobs

Fisherman's Delight

2 pounds pan-dressed yellow perch or other small fish, fresh or frozen.
2 tablespoons lemon juice
2 teaspoons salt
¼ teaspoon pepper
1 pound sliced bacon

Thaw frozen fish. Clean, wash, and dry fish. Brush inside of fish with lemon juice and sprinkle with salt and pepper. Wrap each fish with a slice of bacon. Place fish in well-greased, hinged wire grills. Cook about 5 inches from moderately hot coals for 10 minutes. Turn and cook for 10 to 15 minutes longer or until bacon is crisp and fish flakes easily when tested with a fork. Makes 6 servings.

Charcoal Grilled Seafood

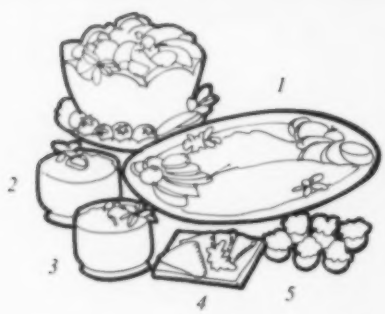
2 pounds red snapper fillets or other fish fillets, fresh frozen
½ cup melted fat or oil
¼ cup lemon juice
2 teaspoons salt
½ teaspoon Worcestershire sauce
¼ teaspoon white pepper
Dash liquid hot pepper sauce
Paprika

Thaw frozen steaks. Cut into serving-size portions and place in well-greased, hinged wire grills. Combine remaining ingredients except paprika. Baste fish with sauce and sprinkle with paprika. Cook about 4 inches from moderately hot coals for 8 minutes. Baste with sauce and sprinkle with paprika. Turn and cook for 7 to 10 minutes longer or until fish flakes easily when tested with a fork. Makes 6 servings.

Pickled Fish

1 pound thick fish fillets, fresh or frozen
1 cup cooked sliced carrots
1 cup thinly sliced red onions
2 cups white vinegar
½ cup sugar
1 teaspoon salt
1 teaspoon mixed pickling spices
Lettuce
Party rye bread, sliced

Thaw and skin frozen fillets. Cut fillets crosswise into ¾-inch slices. Arrange alternate layers of fish and vegetables in a 1½ quart casserole. Combine vinegar, sugar, salt, and spices in a 1-quart sauce pan. Heat to the boiling point. Stir until sugar is dissolved. Pour hot pickling liquid over fish. Cover and chill at least 24 hours to pickle the fish. Stir once or twice during pickling. Serve on lettuce with a slice of rye bread. Makes 6 servings.



1. *Charcoal Grilled Seafood*
2. *Pickled Fish*
3. *New Orleans Crab Spread*
4. *Salmon Flips*
5. *Tuna Tomato Teasers*

Salmonburgers
Tuna Barbecue

1. *Louisiana Shrimp Boil*
2. *Scallop Kabobs*
3. *Italian Style Salmon Steaks*
4. *Fish Fry*
5. *Chesapeake Bay Clambake*

Aloha Seafood Platter

1. *Parmesan Portions On A Roll*
2. *Saucy Seafood Barbecue*
3. *Crab Stuffed Avocado*
4. *Fish-in-Wraps*

Flounder with Crab Stuffing

New Orleans Crab Spread

1 can (12 ounces) blue crabmeat or other crabmeat, fresh or frozen or
2 cans (6½ or 7½ ounces each) crabmeat
¼ cup tarragon vinegar
⅓ cup mayonnaise or salad dressing
3 tablespoons chopped pimiento
2 tablespoons chopped green onion
1 teaspoon salt
½ teaspoon freshly ground pepper
1 tablespoon drained capers
Assorted chips, crackers, or raw vegetables

Thaw frozen crabmeat. Drain crabmeat. Remove any remaining shell or cartilage. Flake the crabmeat. Pour vinegar over crabmeat. Chill for 30 minutes. Drain. Add mayonnaise, pimiento, onion, salt, and pepper. Mix thoroughly. Garnish with capers. Serve with chips, crackers, or vegetables. Makes approximately 2 cups.

Salmon Flips

1 can (1 pound) salmon
4 slices bacon
¾ cup condensed Cheddar cheese soup
1 teaspoon horseradish
1 teaspoon instant minced onion
Dash pepper
Cheese Canape Pastry

Drain and flake salmon. Fry bacon until crisp. Drain on absorbent paper. Crumble. Combine all ingredients except pastry. Roll pastry very thin and cut in 2½ inch squares. Place a heaping teaspoonful of salmon mixture on one half of each square. Fold over and press edges together with a fork. Place turnovers on a baking pan, 15 by 10 by 1 inch. Prick top to allow steam to escape. Bake in a very hot oven, 450° F., for 10 to 12 minutes or until lightly browned. Makes approximately 80 hors d'oeuvres.

Tuna Barbecue

2 cans (6½ or 7 ounces each) tuna
½ cup chopped onion
2 tablespoons tuna oil
½ cup chopped celery
½ cup chopped green pepper
1 cup catsup
1 cup water
2 tablespoons brown sugar
2 tablespoons vinegar
2 tablespoons Worcestershire sauce
1 teaspoon prepared mustard
½ teaspoon salt
Dash pepper
6 hamburger rolls

Drain tuna, reserving oil. Break tuna into large pieces. Cook onion in oil until tender in a large kettle over hot coals. Add remaining ingredients except tuna and rolls. Simmer uncovered for 20 minutes, stirring frequently. Add tuna and simmer 10 minutes longer, stirring frequently. Split rolls and toast. Place approximately ½ cup tuna mixture on bottom half of roll. Cover with top half of roll. Serves 6.

Louisiana Shrimp Boil

5 pounds shrimp, fresh or frozen
1 gallon water
1 lemon, sliced
1 small onion, sliced
½ cup salt
½ cup seafood seasoning
1 clove garlic, sliced
Seafood cocktail sauce

Thaw frozen shrimp. Pour water into a large kettle. Add seasonings. Cover and bring to the boiling point over hot coals. Add shrimp. Cover and simmer for 5 minutes. Drain. Serve with seafood cocktail sauce. Serves 6.

Salmonburgers

1 can (1 pound) salmon
½ cup chopped onion
¼ cup melted fat or oil
1/3 cup salmon liquid
1/3 cup dry bread crumbs
2 eggs, beaten
¼ cup chopped parsley
1 teaspoon powdered mustard
½ teaspoon salt
½ cup dry bread crumbs
1/3 cup mayonnaise or salad dressing
1 tablespoon chopped sweet pickle
6 buttered hamburger rolls

Drain salmon, reserving liquid. Flake salmon. Cook onion in fat until tender. Add salmon liquid, crumbs, egg, parsley, mustard, salt, and salmon; mix well. Shape into 6 burgers. Roll in crumbs. Fry in hot fat in a heavy fry pan about 4 inches from hot coals for 3 minutes. Turn carefully and fry for 3 to 4 minutes longer or until brown. Drain on absorbent paper. Combine mayonnaise and pickle. Place burgers on bottom half of each roll. Top with approximately 1 tablespoon mayonnaise mixture and top half of roll. Serves 6.

Tuna Tomato Teasers

1 can (6½ or 7 ounces) tuna
1 package (3 ounces) cream cheese, softened
1 ripe avocado, mashed
1 tablespoon lemon juice
1 teaspoon chili powder
½ teaspoon salt
½ teaspoon liquid hot pepper sauce
½ teaspoon Worcestershire sauce
2 pints cherry tomatoes

Drain and flake tuna. Cream the cheese and avocado. Add seasonings and tuna. Mix thoroughly. Chill. Wash tomatoes and hollow out centers. Turn upside down to drain. Fill each tomato with a heaping teaspoonful of tuna mixture. Makes approximately 40 hors d'oeuvres.

Fish Fry

2 pounds ocean perch fillets or other fish fillets, fresh or frozen
¼ cup evaporated milk
1½ teaspoons salt
Dash pepper
½ cup flour
¼ cup yellow cornmeal
1 teaspoon paprika

Thaw frozen fillets. Cut into serving-size portions. Combine milk, salt, and pepper. Combine flour, cornmeal, and paprika. Dip fish in milk mixture and roll in flour mixture. Fry in hot fat in a heavy fry pan about 4 inches from hot cals for 4 minutes. Turn carefully and fry for 4 to 6 minutes longer or until fish is brown and flakes easily when tested with a fork. Drain on absorbent paper. Serves 6.

Italian Style Salmon Steaks

2 pounds salmon steaks or other fish steaks, fresh or frozen
2 cups Italian dressing
2 tablespoons lemon juice
2 teaspoons salt
¼ teaspoon pepper
Paprika

Thaw frozen steaks. Cut into serving-size portions and place in a single layer in a shallow baking dish. Combine remaining ingredients except paprika. Pour sauce over fish and let stand for 30 minutes, turning once. Remove fish, reserving sauce for basting. Place fish in well-greased, hinged wire grills. Sprinkle with paprika. Cook about 4 inches from moderately hot coals for 8 minutes. Baste with sauce and sprinkle with paprika. Turn and cook for 7 to 10 minutes longer or until fish flakes easily when tested with a fork. Serves 6.

Chesapeake Bay Clambake

6 dozen soft-shell clams
12 small onions
6 medium baking potatoes
6 ears of corn in the husks
12 live, hard-shell blue crabs
Lemon wedges
Melted butter or margarine

Wash clam shells thoroughly. Peel onions and wash potatoes. Parboil onions and potatoes for 15 minutes; drain. Remove corn silk from corn and replace husks. Cut 12 pieces of cheesecloth and 12 pieces of heavy-duty aluminum foil, 18 x 36 inches each. Place 2 pieces of cheesecloth on top of 2 pieces of foil. Place 2 onions, a potato, ear of corn, 1 dozen clams, and 2 crabs on cheesecloth. Tie opposite corners of the cheesecloth together. Pour 1 cup of water over the package. Bring foil up over the food and close all edges with tight double folds. Make 6 packages. Place packages on a grill about 4 inches from hot coals. Cover with hood or aluminum foil. Cook for 45 to 60 minutes or until onions and potatoes are cooked. Serve with lemon wedges and butter. Serves 6.

Scallop Kabobs

1 pound scallops, fresh or frozen
1 can (13½ ounces) pineapple chunks, drained
1 can (4 ounces) button mushrooms, drained
1 green pepper, cut into 1-inch squares
¼ cup melted fat or oil
¼ cup lemon juice
¼ cup chpped parsley
¼ cup soy sauce
½ teaspoon salt
Dash pepper
12 slices bacon

Thaw frozen scallops. Rinse with cold water to remove any shell particles. Place pineapple, mushrooms, green pepper, and scallops in a bowl. Combine fat, lemon juice, parsley, soy sauce, salt, and perper. Pour sauce over scallop mixture and let stand for 30 minutes, stirring occasionally. Fry bacon until cooked but not crisp. Cut each slice in half. Using long skewers, alternate scallops, pineapple mushrooms, green pepper, and bacon until skewers are filled. Cook about 4 inches from moderately hot coals for 5 minutes. Baste with sauce. Turn and cook for 5 to 7 minutes longer or until bacon is crisp. Serves 6.

Aloha Seafood Platter

1 7½ ounce can salmon
1 7½ ounce can tuna
1 small pineapple or a No. 2 or 2-½ size can of pineapple
1 avocado
Juice of 1 lemon
1 papaya
2 small cans mandarin oranges
1 cup commercial sour cream
Grated peel and juice of 1 lime
¼ cup finely chopped chutney
1 cup macadamia nuts (chopped)

Drain salmon and tuna. Break into large chunks and arrange in center of a large platter, about 12 by 18 inches. Peel pineapple, remove eyes, and slice into rounds, halve the slices removing the core, or substitute well-drained canned pineapple. Arrange a row of pineapple on one side of platter. Halve, peel, and slice the avocado, dip each slice in lemon juice. Peel, halve, remove seeds, and slice papaya. Drain mandarin oranges. Arrange papaya in a row beside the pineapple. On the opposite side of plitter arrange slices of avocado and the mandarin oranges. Garnish with marachino cherries and lime slices, if desired. Cover the platter with plastic film and chill. Mix the sour cream with the grated peel and juice of the lime, add chopped chutney. Chill. Serve dressing and nuts in separate small bowls at serving time. Makes 6 servings.

Parmesan Portions On A Roll

6 frozen raw breaded fish portions (2½ ounces each)
½ cup grated Parmesan cheese
1 tablespoon chorped parsley
1 teaspoon oregano
1 teaspoon garlic powder
1 teaspoon paprika
½ cup melted fat or oil
6 sesame rolls
Tartar Sauce

Combine cheese, parsley, oregano, garlic powder, and paprika. Mix thoroughly. Dip frozen portions in fat and roll in cheese mixture. Place portions on a well-greased grill about 4 inches from moderately hot coals. Cook for 5 to 7 minutes. Turn.Cook for 5 to 7 minutes longer or until fish flake easily when tested with a fork. Toast rolls. Place 1 portion on bottom half of roll. Top with approximately 1 tablespoon of Tartar Sauce and top half of roll. Makes 6 servings.

Tartar Sauce

¼ cup mayonnaise or salad dressing
2 tablespoons drained sweet pickle relish
1 teaspoon instant minced onion
1 teaspoon lemon juice

Combine all ingredients. Mix thoroughly. Chill. Makes approximately ½ cup of sauce.

Saucy Seafood Barbecue

2 pounds fish fillets, fresh or frozen
1 cup chili sauce
¼ cup lime juice
2 tablespoons French dressing
1 tablespoon brown sugar
2 teaspoons cider vinegar
2 teaspoons prepared mustard
1½ teaspoons salt
½ teaspoon Worcestershire sauce
Lime wedges

Thaw frozen fillets. Cut fillets into 6 portions. Place fish in well-greased, hinged, wire grills. Combine all ingredients except lime wedges. Mix thoroughly. Baste fish with sauce. Cook about 4 inches from moderately hot coals for 5 to 7 minutes. Baste with sauce. Turn. Cook for 5 to 7 minutes longer or until fish flake easily when tested with a fork. Garnish with lime wedges. Makes 6 servings.

Crab Stuffed Avocado

1 pound crab meat, fresh or frozen
or
3 cans (6½ ounces each) crab meat
½ cup chopped celery
1/3 cup mayonnaise or salad dressing
2 hard-cooked eggs, chopped
2 tablespoons chopped red or green pepper
2 tablespoons drained sweet pickle relish
1 tablespoon lemon juice
½ teaspoon salt
Dash pepper
3 avocados
Salad greens
Tomato wedges

Thaw frozen crab meat. Drain crab meat. Remove any remaining shell or cartilage. Combine celery, mayonnaise, egg, red pepper, pickle relish, lemon juice, salt, pepper, and crab meat. Mix thoroughly. Chill. Cut avocados in half lengthwise. Remove seed and peel. Fill avocado halves with crab mixture. Serve on salad greens. Garnish with tomato wedges. Makes 6 servings.

Fish-In-Wraps

3 pounds pan-dressed fish, fresh or frozen
¾ cup melted fat or oil
1 package (1¾ or 1⅞ ounces) onion soup mix
¼ teaspoon pepper
½ pound sliced bacon

Thaw frozen fish. Clean, wash, and dry fish. Combine remaining ingredients except bacon. Mix thoroughly. Brush inside and outside of fish with sauce. Wrap each fish with a slice of bacon. Place fish in well-greased, hinged wire grills. Cook about 5 inches from moderately hot coals for 10 to 15 minutes. Baste with sauce. Turn. Cook for 10 to 15 minutes longer or until fish flake easily when tested with a fork. Makes 6 servings.

Flounder with Crab Stuffing

6 pan-dressed flounder (¾ pound each), fresh or frozen
Crab stuffing
¾ cup butter or margarine, melted
1/3 cup lemon juice
2 teaspoons salt
Paprika

Thaw frozen fish. Clean, wash, and dry fish. To make a pocket for the stuffing lay the fish flat on a cutting board, light side down. With a sharp knife cut down the center of the fish along the backbone from the tail to about 1 inch from the head end. Turn the knife flat and cut the flesh along both sides of the backbone to the tail allowing the knife to run over the rib bones.

Stuff fish loosely. Combine butter, lemon juice, and salt. Cut 6 pieces of heavy-duty aluminum foil, 18 x 18 inches each. Grease lightly. Place 2 tablespoons sauce on foil. Place fish in sauce. Top each fish with 1 tablespoon sauce and sprinkle with paprika. Bring the foil up over the fish and close all edges with tight double folds. Make 6 packages. Place packages on a grill about 6 inches from moderately hot coals. Cook for 25 to 30 minutes or until fish flakes easily when tested with a fork. Serves 6.

Crab Stuffing

1 pound crab meat, fresh or frozen
or
3 cans (6½ or 7 ounces each) crab meat
½ cup chopped onion
1/3 cup chopped celery
1/3 cup chopped green pepper
2 cloves garlic, finely chopped
1/3 cup melted fat or oil
2 cups soft bread cubes
3 eggs, beaten
1 tablespoon chopped parsley
2 teaspoons salt
½ teaspoon pepper

Thaw frozen crab meat. Drain crab meat. Remove any remaining shell or cartilage from crab meat. Cook onion, celery, green pepper, and garlic in fat until tender. Combine bread cubes, eggs, parsley, salt, pepper, cooked vegetables and crab meat; mix thoroughly.

Smoked Fish Timetable

Market form of fish	Amount for 6 servings	Length of time to marinate in brine	Cooking temperature	Approximate cooking time
Butterfly fillets (including bone, 1 pound each)	6 pounds	30 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 30 min. 45 min. 30 min.
Fillets or steaks (½ inch thick)	2 pounds	30 minutes	150°-175°F. 200°F. 250°F.	1 hr. 30 min. 20 min.
Fillets or steaks (¾ inch thick)	2 pounds	45 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 30 min. 30-45 min. 30 min.
Fillets or steaks (1 inch thick)	2 pounds	45 minutes	150°-175°F. 200°F. 250°F.	1 hr. + 45 min. 30-45 min. 30 min.
Fillets or steaks (1½ inches thick)	2 pounds	1 hour	150°-175°F. 200°F. 250°F.	2 hours 1 hr. + 15 min. 45-50 min.
Pan dressed	3 pounds	30 minutes	150°-175°F. 200°F. 250°F.	2 hours 1 hr. + 15 min. 45-50 min.

Note: Use oven thermometer to check temperature in charcoal grill. The same results can be accomplished using an electric or gas grill.
To make brine combine 1 gallon water and 1 cup salt. Stir until dissolved.

Three big ones:

Sportfishing, Wetlands, and the 200-Mile Zone

By GERALD D. HILL, JR.

THE effect of the Fishery Conservation and Management Act of 1976 on recreational fishing was the major topic of discussion during the Marine Recreational Fisheries Symposium held in San Francisco in April.

The meeting was attended by more than 100 people from all over the world who are vitally interested in recreational fishing. They came from the Western Pacific—Pago Pago, Guam—from Mexico, France, and Canada as well as from most of the coastal states.

The Act opens new areas of consideration in the development of management schemes for all marine fisheries and dictates that the role of the recreational fisherman be considered by those who develop the plans which will regulate the stocks of fish within 200 miles of our shores.

The Symposium was established in 1976 in recognition of the need for a national forum to discuss environmental and conservation concerns affecting U.S. fisheries. It was organized by the International Game Fish Association, the Sport Fishing Institute, and the National Coalition for Marine Conservation to demonstrate a single basis for marine fisheries programs—that of economics.

"The International Game Fish Association, with over 20,000 members throughout the United States and in foreign countries, is involved with record keeping, historical and ethical angling techniques, and rules of the recreational fishing community," says Dr. Frank Carlton, President of the National Coalition for Marine Conservation, who chaired the two-day session. "The Sport Fishing Institute also has over 20,000 members and has served over the years to stimulate scientific and educational programs of interest to recreational fishing. Our Coalition is much smaller and has only been organized for about four years. It does, however, have a central cadre of representatives on almost every significant national and international council, commission, and other groups which administer, advise, or indirectly affect ocean and fisheries matters," said Carlton.

Why does the Act have such an impact on recreational fishermen?

"The Fishery Conservation and Manage-

ment Act is a means of improving management of marine fisheries which rely on management plans developed by the eight Regional Fishery Management Councils," said Dr. Brian Rothschild, Director, Office of Policy Development and Long Range Planning for the National Marine Fisheries Service.

The Regional Fishery Management Councils were established under the Act. They consist of members appointed by the Secretary of Commerce from nominations made by the governors of the coastal states that are members of the councils as well as members of the Federal and state governments which are involved with fisheries.

The central theme of the management plans is the determination of the optimum yield of each of the fisheries. This is a new concept that requires that a yield be determined that provides the greatest overall benefit to the Nation with particular reference to food production and recreational opportunities. In order to provide this, social, economic, and ecological factors must be considered in the development of all plans.

"All aspects of a fishery must be considered in determining optimum sustainable yield," said Rothschild. "Each of the different aspects will carry different weights and values and it will be very difficult to determine which factor carries the most weight."

To demonstrate the complexity of the process, Dr. Rothschild gave as an example a fishery that might be fished by recreational fishermen, domestic commercial fishermen, and fishermen from other countries. "All of these people have valid concerns," said Rothschild. "The commercial fisherman wants to improve his way of life. The processor wants to have the most favorable rate of return in his business. And the consumer wants to have the right kind of products at the right price and quality in the market.

"It should be clear that it is difficult to satisfy simultaneously all of these groups involved with a particular stock. Any management decision related to any one group will probably affect all of the other groups. If we do not consider all groups, then there may be some individuals who are affected positively or negatively. If we do not appreciate the gains and losses of each group then it will be difficult to know whether our fishing management decision is indeed the best," Rothschild said.

"This is much easier to say than do, nevertheless we have made a start. If we are to make better decisions, we will have to enhance our research in the social, economic, and biological areas and collect new kinds of data in a more systematic way," he said.

Robert W. Schoning, Director, NMFS, echoed Rothschild's statement on the need for additional data when he addressed the group. "I have been deeply concerned for a long time about the great lack of sufficiently detailed information on recreational fishery catches in our marine waters. We must have more data on the recreational fishing industry, its components, the relationships, the importance, and the extent. We have been making far less progress on this than we have desired, however, we are at least getting started on some of this and I am convinced work will accelerate," Schoning said.

Philip A. Meyer, Chief Special Service Advisor Habitat Protection Directorate for Fisheries and Marine Services in Canada, presented his ideas on the social aspects of the 200-mile zone, information needed, and means of collecting the information that the Fishery Management Councils require in considering recreational fishing in their management plans.

"In the past the nature and magnitude of benefits provided by recreational fishing have only been considered superficially," says Meyer. "Fish for recreation have been allotted out of commercial catches and the search for biological information to be used in fishing models has been treated as a sufficient base for decision makers," he said. "No one wants to allot part of a commercial recreational catch to marine recreational fishing. The councils must now weigh the benefits, to themselves and to the Nation, of shifting small increments of fish between commercial fishing and recreational fishing or between one type of recreational fisherman and another."

According to Meyer the question for the councils to decide is how much to shift and for what purposes. He says the councils have the information to decide in which direction to shift but don't know how far or how much they should shift from one recreational fishery to another.

"The surveys and information available are not adequate for the decision that is required," Meyer said. "We should ask ourselves some questions. Do people decide what state, town, or neighborhood they will live in because of the recreational fishing opportunities in the area? What are the physical and emotional health benefits derived from marine recreational fishing? What are the attitudes developed in children because of recreational fishing? How are people's values and views of recreational fishing changing? How and why are we losing sportsmen; do they get fed up and quit or do we lose the children before they start? Most important, how can we win them back?"

Meyers said the collection of this type of information must be weighed against the effort required and the results obtained. "The creation of the regional councils represents a great opportunity for marine recreational fishing," Meyers said. "The Act requires that recreational fishing receive full and equitable treatment. It demands that benefits to the

Three speakers at the Marine Recreational Fisheries Symposium were (top photos, left to right) Dr. Brian Rothschild, NMFS, discussing the effects of optimum sustainable yield on recreational fishermen; Richard Stone, NMFS, talking on the uses and effects of artificial reefs; and Dr. Frank Carlton, President of the National Coalition for Marine Conservation, talking to the opening session.....and the audience also participated; here a questioner quizzes one of the panels during the two-day session.

people be the focal point of the plans produced by the councils."

He feels the councils are in a position to gain from traditional information and expertise but need to build upon this information by having a more contemporary thrust.

"One must go beyond biological research and develop a more balanced program of information and research and have a more serious concern for the benefits derived, especially the recreational benefits. Don't do away with traditional fishery knowledge and science but integrate it with new knowledge and new science and new needs," he told the group.

The environment and its effect on recreational fishing was of particular interest to those who attended. Economic losses caused by habitual destruction from estuarine pollution, dredging, landfill, and ocean dumping, as well as methods of enhancing and developing marine habitats, were among the problems discussed.

Dr. Allen Hirsch, Chief of Biological Service of the Fish and Wildlife Service, told the group that habitat destruction has had a profound impact on recreational fishing. A 1967 study has shown that over a 20-year period, seven percent of the estuarine areas had been destroyed by filling and other commercial development. A 1970 study showed that 23 percent of all estuarine areas had been severely modified by man and another 50 percent moderately modified. He estimated that 40 percent of the coastal wetlands had been lost.

"Loss of these wetlands can have three impacts on recreational fishing," says Dr. Hirsch. "First, there is a reduction in fish populations. Second, the fish populations remain the same but become contaminated and unpalatable or unsafe for human consumption. Third, the areas become unattractive to fishermen and they won't fish there. In some areas, access is so reduced that they just can't fish in the area."

He feels, however, that continuing progress is being made in treating industrial waste and that ocean dumping will be more strictly controlled. Severe restrictions on the use of wetlands and water diversions will also assist us in reducing man's destruction of the environment required for healthy fish stock.

"Environmental considerations are as important to the management question of recreational fishermen as the basic question of management of stocks," said Dr. Hirsch.

Richard R. Gardner, Deputy Director, Office of Coastal Zone Management in NOAA, told the group that almost everyone agrees that there should be some level of protection of wetlands. "Differences occur on the extent of the protection and whether the states or the Federal Government should protect them," he said.

Wetlands are important because they serve as a source of food, shelter, and breeding for fish and shellfish. They also purify water, provide storm and flood protection, and provide areas of unsurpassed natural beauty, Gardner told the attendees.

The Office of Coastal Zone Management is assisting states in the development of plans that will give high priority to wetland protection. California, Oregon, and Massachusetts were named by Gardner as examples of states where local communities have pulled together to arrive at goals and established coordinated state-local effort to control wetland use.

Coastal Zone Management is directing other programs which will have an impact on recreational fishing. The Estuarine Sanctuary Program serves as a research and data resource in the development and implementation of state coastal zone programs. Both Georgia and Oregon have these programs underway and both specifically permit recreational fishing. Some time in the future, as many as 20 such programs may be developed on all coasts and on the Great Lakes.

Two marine sanctuaries have been established. The first is off North Carolina at the site of the U.S.S. Monitor and the other in a coral area off Key Largo in Florida. "These are significant to the recreational fishermen in that they provide a means of control of the activity permitted in the area," said Gardner. "They protect a specific resource but also permit the recreational fishermen to use the sanctuaries."

Recent amendments to the CZM Act authorize the Office to provide matching funds on a 50/50 basis to states to permit them to acquire land for access to boat ramps and fishing areas that can be used by the recreational fishermen, according to Gardner.

Even though a lot of the coastal lands have been destroyed or harmed by man, all is not lost, according to Richard Stone.

Stone, Acting Director for Recreational Fisheries in the National Marine Fisheries Service, is one of the country's leading authorities on the development of artificial reefs.

"Construction and wise use of artificial reefs can help to achieve the goal of developing and implementing management tools and practices to conserve and enhance fishery resources," he told the group.

"Reefs have potential to become practical management tools by developing quality fishing grounds close to access areas, increase stock size of reef fishes, and benefit anglers and economies of local communities." Artificial reefs must be managed by qualified individuals with adequate financial support, according to Stone. "They must be situated properly so they don't conflict with navigation or commercial fishing, and non-toxic materials that won't shift must be used," said Stone.

"Most reefs have been placed on relatively barren stretches of ocean bottom, close to inlets. Their use should be expanded in this manner and they should also be used in areas where rough bottom exists.

"Studies have shown that artificial reefs have doubled the carrying capacity in the areas of natural reefs and just don't serve to concentrate the fish," he said.

The United States is not the only country showing an interest in recreational fishermen. D. J. Stern of Canada says that his country is becoming more aware of recreational fishing, not only economically, but also because of the impact on the resources. "A national survey has shown that over 3.5 million anglers spend over one billion dollars, and in many areas catch more fish than are being caught by commercial fisherman," said Stern.

Canada has taken several steps to assist the marine recreational fishermen. It placed limitations on the types of gear that can be used to catch bluefin tuna and closed many commercial fisheries for Atlantic salmon.

"Canada's commitment to promote recreational fishing is evident in many projects it has undertaken and in the proposed Pacific salmon enhancement program, primarily designed to increase angling," Stern said. "Additional evidence of Canada's interest was shown with the establishment of a separate recreational fishing branch in 1973. This branch is responsible for developing new national recreational fishery policy," he said.

Mexico has increased its efforts to expand its fishing activities. Mr Fernando Rafful, Director of the Department of Fisheries, says that his department, equivalent to Cabinet rank in this country, is entrusted with the management and development of the country's resources to meet the basic food, employment, and monetary demands.

"We cannot allow ourselves to disregard any one aspect of the fishing activities," Rafful said. "We feel it is our moral duty to consider them all. This is why we suggest the development of recreational fishing in order to bring about its present and future use within a humanistic concept."

"We are drafting new fishing regulations to explicitly and precisely embody all measures tending to foster recreational fishing," he told the group. "We are easing the paperwork for licenses required by our foreign visitors so that they may more easily enjoy our many varieties of recreational fishing. We attach special importance to the cooperation among the United States, Canada, and Mexico for developing a system to gather information on recreational fishing whose joint use will bring about a better management of this activity in order to optimize the use of our recreational fishery without overexploiting it," said Rafful.

"We feel that these programs will result in better conditions and facilities for fishermen interested in recreational fishing in our country," he concluded.

Many topics of interest to all recreational fishermen were discussed during the meeting. Although much progress has been made since the Act was passed, many who attended feel that much remains to be done. Robert Schoning perhaps summed up the feeling of the group when he said, "Enactment of the 200-mile zone, Fishery Conservation and Management Act, stands with the establishment of our national forests as landmark legislation in further conservation of our nation's natural resources.

"Although we have come a long way, during the past year, much remains to be done. There's no question in my mind we'll have difficulties and break downs. Seldom, if ever, do new programs of such magnitude and complexity get started without a hitch. What is important is that the purpose, structure, and implementation of our extended jurisdiction law provide a pattern for the world to follow."

THE OPENING OF THE JAMES

ON FEBRUARY 24 the sulfur tanker Marine Floridian, its rudder stuck to port, struck the 4,463-foot Benjamin Harrison Memorial Bridge near Hopewell, and the James River, one of Virginia's most vital waterways, was abruptly closed.

The collision knocked 110 feet of the bridge and 240 feet of the truss into the river's main channel, suspending vital shipping between the Richmond area and the port of Norfolk. The closing of the river particularly affected those businesses in Central and Western parts of Virginia dependent on the upper James for fuel shipments and other supplies from Norfolk.

At the request of the U.S. Coast Guard's Marine Safety Office, NOAA's Atlantic Marine Center, the home of the nation's only wire drag ships constructed especially to locate underwater navigation hazards, dispatched the Rude and Heck to sweep the area adjacent to the partially collapsed bridge.

After three days of operations, the Rude and Heck cleared the southern auxiliary channel to 18 feet, and limited barge traffic on the James was resumed. Two days later, however, the north tower of the bridge's lift span, tilted since the collision, fell into the river. Again, the Rude and Heck were called in to clear the channel of all debris—but this time to the least depth of 24 feet, based on predicted tides. This required the acquisition of a new drag device designed for use in small areas by Great Britain's Royal Navy Hydrographic Division.

The system consists of a constant tensioning machine containing a spool of 1/32" piano wire. The wire is stretched between two launches and lowered to the desired drag depth by use of a weighted 1/4" wire fed through a gallows. Ideal conditions occur when the launches are able to drift, under minimum power, so that the weighted wire hangs vertically in the water. The constant tensioning machine holds wire sags to a minimum between the supporting uprights.

To assist the Rude and Heck in the proper use of the British system, Lt. Cdr. William Frisken of the Royal Navy's Hydrographic Office Survey Division came aboard as an adviser. Lt. Cdr. Frisken is presently stationed at the U.S. NAVOCEANO Base at Bay St. Louis, Miss., as the hydrographic liaison officer between the U.S. and Great Britain.

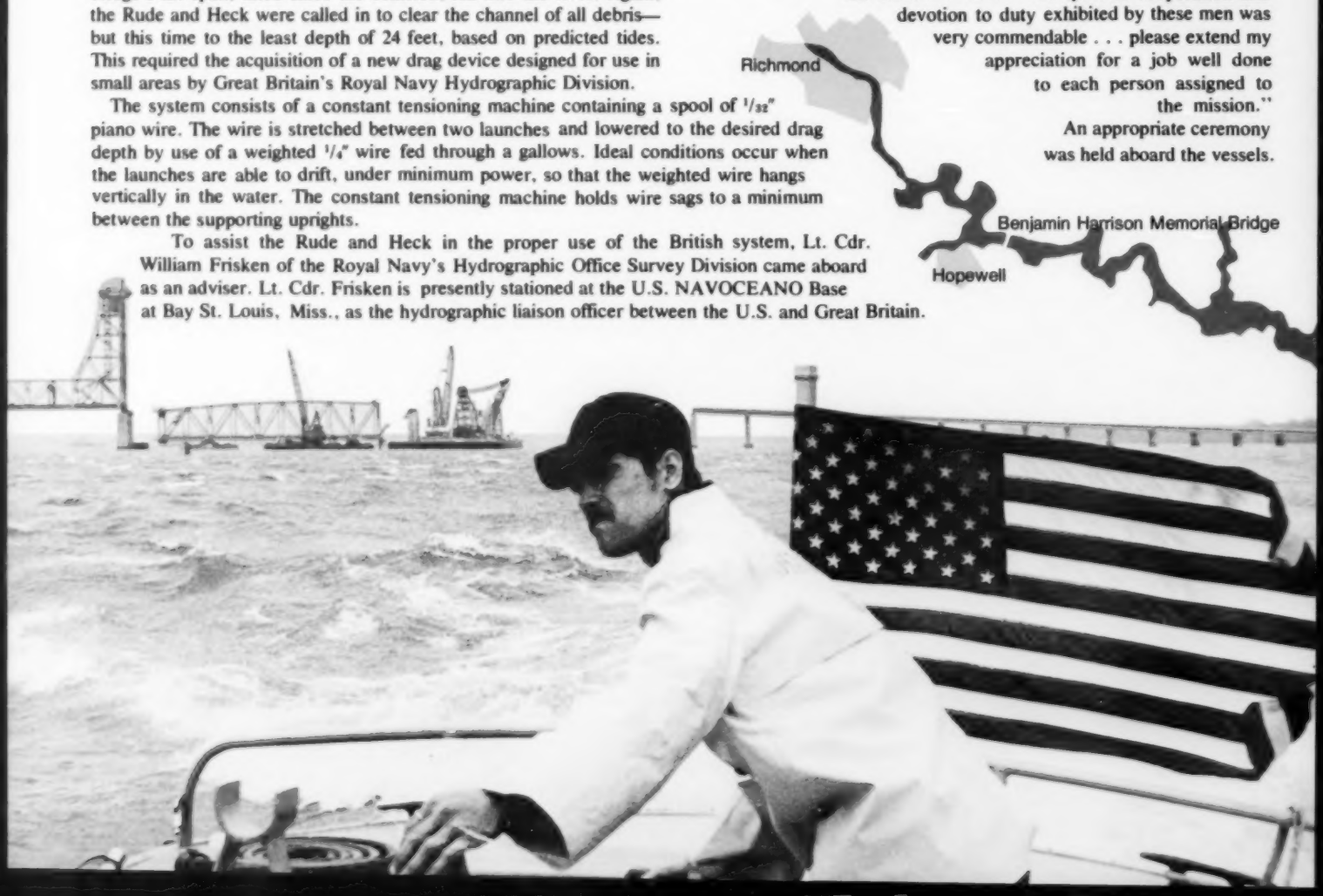
According to Ens. Samuel P. DeBow, Jr., of the Rude and Heck, during the first few days a number of hangs were encountered with the new machinery. "It was evident," he said, "that something was protruding from the bottom which could possibly hinder safe navigation through the main channel."

This information was relayed to a salvage company at the scene which later found a boiler of riveted construction protruding six feet from the bottom. "After its removal," said DeBow, "the company then swept a 150-foot steel beam through the channel in order to knock down any small protrusions."

On March 24, exactly one month following the date of the accident, the Coast Guard opened the James River to unlimited traffic. A week later, R. Adm. Robert C. Munson, Director of NOAA's Atlantic Marine Center, received a letter from Capt. C. R. Thompson, of the U.S. Coast Guard and Captain of the Port of Hampton Roads, Va.

"While I realize that operations of this nature depend on the successful cooperation of many individuals," wrote the Captain, "I make special note of Commander (Robert A.) Ganse and the crews of the Rude and Heck. The spirit of cooperation and devotion to duty exhibited by these men was very commendable . . . please extend my appreciation for a job well done to each person assigned to the mission."

An appropriate ceremony was held aboard the vessels.



Photos: John Roseborough, NOAA

Left: Cdr. Robert A. Ganse and Chief Boatswain William Brooks, of the National Ocean Survey's Rude/Heck, dismantle the 500 pound wire drag system. Top: W. E. Winfrey, Asst. District Engineer for the Richmond Area (left), Lt. Dean Harder (center) and Cdr. Russell Sawyer (right), of the U.S. Coast Guard, discuss plans for removing bridge wreckage. Above left: the wire drag system is designed to work in tight places. Above right: T-shirts 'commemorating' the event are on sale at the local marina. Below: Kenneth Soper, engineer and photographer for the Va. State Highway Department, records all salvage activities.

Photos: John Roseborough, NOAA

noaa/update

A perfect launch

GOES SATELLITE IN ORBIT

A new environmental monitoring satellite, to be positioned to keep watch over the eastern half of the United States and the Atlantic Ocean, was launched June 16 just in time for this year's hurricane season.

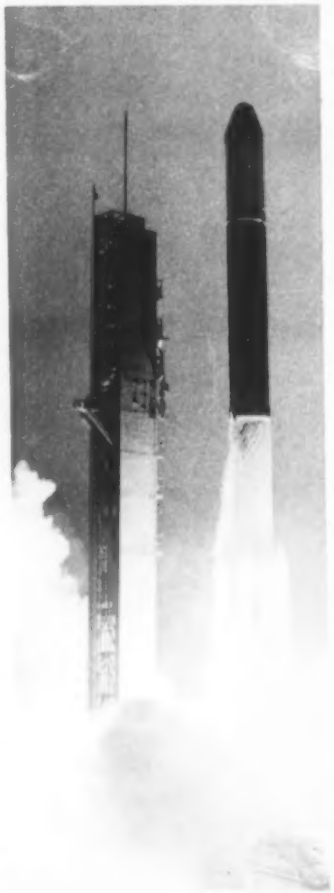
The satellite, GOES–B, is the latest in a series of Geostationary Operational Environmental Satellites to be operated by NOAA.

The spacecraft was launched about 6:51 a.m. EDT by NASA from Kennedy Space Center in Florida. It was placed into an earth synchronous orbit at an altitude of about 22,300 miles (35,800 kilometers) with a velocity which will keep it in position over the equator above South America. Now in orbit, the satellite is known as GOES–2.

From the position, instruments aboard the satellite let it "see" the development of hurricanes in the tropical Atlantic or Caribbean, and follow any storm's movement. The satellite routinely transmits imagery back to earth every half hour, day and night; more frequently when necessary.

GOES–2 replaces an earlier spacecraft of the same series in maintaining the East Coast and Gulf watch. Another satellite of the series is positioned above the equator over the Pacific Ocean, watching the western half of the United States and the Pacific as far west as Hawaii.

While hurricane watch is an important mission of the satellite, it is far from the only responsibility, according to David S. Johnson, Director of NOAA's National Environmental Satellite Service. Originally conceived as weather satellites, the geostationary spacecraft do provide a host of data of importance to weather forecasters. They use both visual and infrared imagery for severe storm evaluation and to analyze cloud cover, winds, ocean currents, fog distribution, storm circulation, snow melt, and other environmental phenomena.



"Seagranti:" A New Word in Taxonomy

The Office of Sea Grant may not go on forever, but unless disaster overcomes marine life off Guam, its name appears destined for immortality.

The reason is that Sea Grant scientists at the University of Guam have discovered two new species of stone crabs. Because their work had been carried out under the auspices of the NOAA agency, they showed their appreciation by naming one of the species P. Seagranti.

NMFS Inspects Fish Products

The inspection of certain fish products for the Armed Forces has been transferred from the Department of Defense to the Department of Commerce, Commerce Secretary Juanita M. Kreps has announced.

Inspectors from National Marine Fisheries Service will assume the responsibility from the Defense Logistics Agency. The Fisheries Service currently inspects over 800 million pounds of fisheries products annually under its voluntary, fee-for-service program.

"Under our contract inspection service, special attention is given to plant sanitation, product safety and wholesomeness, quality, species identification, and proper labeling for either fresh or processed fish products," Thomas J. Billy, Chief of NMFS's Seafood Quality and Inspection Division, said.

Alaskan Gas Seep May Point To Rich Oil Deposit

Nature is giving scientists with NOAA and the U.S. Geological Survey an advance look at the possible environmental effects of tapping Alaska offshore oil deposits through what is believed to be a gas seep on the floor of Norton Sound—in effect a natural source of petroleum hydrocarbons.

Dr. Joel Cline of NOAA's Pacific Marine Environmental Laboratory has found an area in the Sound with unusually high concentrations of natural gas components. He and Dr. Mark L. Holmes of the Geological Survey, who contributed the background information on the geology of the area necessary to interpret Cline's results, believe the gas seeps upward from a deposit of petroleum beneath the floor of the Sound.

Such a seep would be more than a confirmation of the richness of the area's resources, according to Cline: it would allow scientists to measure the effects of petroleum introduced into Alaskan waters before offshore oil drilling and transportation actually begin there.

The possible seep was found about 24 miles (40 kilometers) south of Nome, in an area where Cline had been making a survey of the abundance of hydrocarbons—chemical components of oil and natural gas. His study is part of a major project NOAA is conducting for the Interior Department's Bureau of Land Management. The purpose of the project, managed by NOAA's Outer Continental Shelf Environmental Assessment program office (part of Environmental Research Laboratories), is to provide environmental data that managers can use to predict the impact of oil leasing on the Alaskan Continental shelf.

Cline came upon the possible seep while collecting water samples last September from the NOAA ship Discoverer. The samples, taken from different depths in the water column, were routinely analyzed with a gas chromatograph for various hydrocarbons.

With these measurements, he and Holmes mapped out the concentrations of hydrocarbons as they vary throughout the waters of the Sound, and discovered an area unusually rich in these chemicals. The concentration of ethane, for example, is 20 times higher there than in waters to the south and east.

The hydrocarbons seem to emanate from a point on the sea floor and drift northward toward the coast, say the scientists.

Workshop Held For TV Media

Weathercasters and film crews from more than 20 TV stations as widely separated as Hartford, Conn., and the Rio Grande Valley of Texas converged on Miami, Fla., to learn more about hurricanes. During the national workshop, the TV forecasters shot a lot of film and conducted interviews with NOAA officials–below, Neil Frank, Director National Hurricane Center.

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Coastal Funds Allotted

The first allotments of funds to coastal States under the Coastal Energy Impact Program, totaling $125 million, has been announced by Secretary of Commerce Juanita M. Kreps. Funds allotted will go to 30 states and three territories.

State governors were notified of the fiscal 1977 allotments by the Office of Coastal Zone Management. Two sources of financial assistance created by the 1976 amendments to the Coastal Zone Management Act were used in the allotments, a Coastal Energy Impact Fund, and formula grants.

Purpose of the allotments is to help communities plan for and deal with the effects in the coastal zone of coastal energy development.

Three types of allotments were made from the Fund—credit assistance, which takes the form of loans and guarantees, $110 million; planning grants to enable states better to plan for mitigating the effects of coastal energy development, $3.5 million; and environmental grants, to help the states reduce or repair losses of environmental or recreational resources caused by energy activity, $1.5 million.

Money from the Fund may also be used for activities such as improving or constructing new public facilities and providing new public services that coastal energy development may necessitate. Examples of these are new schools and hospitals, improved roads, and the like.

Formula grant allotments were made on the basis of past, rather than future, coastal energy development. Totaling $10 million, these grants are based on four measures of outer continental shelf activity during fiscal 1976:

—the amount of oil and gas produced adjacent to the State;

—the amount of oil and gas first landed in the State;

—the number of acres leased in waters adjacent to the State;

—the number of people newly employed in OCS activity in the State.

Formula grants are the primary source of assistance to help coastal States and local governments mitigate the unavoidable loss of recreational and environmental resources stemming from coastal energy activity.

ERL Satellite Sensors Warn Space Agencies

NOAA scientists are using satellite sensors to warn space agencies and managers of telecommunications and power transmission systems when disruptive storms and regional disturbances are expected in the earth's magnetic field.

The new system, put into operation recently at ERL in Boulder, Colo., is the only one of its kind in the world, and already has given timely notice of a developing magnetic storm.

Set up by Drs. Joseph N. Barfield and Robert L. McPherron of ERL's Space Environment Laboratory, the system provides a constant, and immediate, visual display of magnetic measurements made by instruments on two satellites.

Magnetometers aboard the spacecraft measure the strength of the earth's magnetic field. Certain changes in the magnetic readings signify magnetic sub-storms—small-scale disturbances that affect a part of the field. The satellite magnetometers also can detect precursors of a sub-storm, such as compression of the earth's magnetic field by an increase in the solar wind—the stream of energetic particles flowing from the sun.

Within a day after the system became operational, it began to indicate a magnetic storm, which magnetometers on earth confirmed two hours later.

Williams, Smart Named New Ship Commanders

Cdr. Bruce I. Williams

Lt. Cdr. Robert V. Smart

Two new commanding officers have been named by the National Ocean Survey: Cdr. Bruce I. Williams to the Fairweather, and Lt. Cdr. Robert V. Smart to the sister ships Rude/Heck.

Cdr. Williams, a native of Seattle, Wash., graduated from the University of Washington, Seattle, Wash., in 1959 with a civil engineering degree. He has had seven years of sea duty aboard five ships; the Fairweather is his third command.

The 231-foot hydrographic survey vessel Fairweather will be working Cook Inlet, Alaska on new, large-scale charting surveys to be used to update existing nautical charts and to provide a new data base for use in ecological, pollution, engineering, fisheries, and other scientific studies.

Lt. Cdr. Smart, a native of Columbus, Ga., is a graduate of the U.S. Naval Academy where he received his B.S. degree in electrical engineering in 1966. After a four-year tour with the Navy, he served aboard the NOS ship Researcher. He was then assigned to NOAA's Office of Environmental Monitoring and Prediction in Rockville, Md., where he participated as one of the controllers during the GATE project.

Before becoming the Rude/Heck commander, he was Fleet Inspection Officer at NOS Headquarters.

The Rude/Heck are the only ones of their kind. The 90-foot 190-ton vessels are designed to obtain information by wire dragging for underwater navigation hazards—sunken wrecks, rocks and other submerged obstacles.

Run, run, run. NOAA personnel are distinguishing themselves and dazzling the competition with their fancy footwork. (Left) National Weather Service Deputy Director Dr. Richard E. Hallgren vies with NWS Headquarters Branch Chief Bernard Edelman in a sprint down the C & O Canal on NOAA Joggers Day, held June 11 in the D.C. area. (Right) Three members of the ERL Great Lakes Environmental Research Laboratory entered and completed the annual 15-mile run from Dexter, Mich, to Ann Arbor, Mich., on May 28. Oceanographer Bob Pickett (left) finished the run in 111 minutes; Physical Scientist Janice Boyd (center), 113 minutes; and Lt. Don Dossett (right), 115 minutes.

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A prototype oil spill recovery boat, for which research was supported by the National Sea Grant Program, undergoes sea-going tests in Tampa, Fla. The project, under the direction of University of South Florida physicist Joe Turbeville, involves the use of ferromagnetic foam, which is released by the boat over an oil spill. The particles of foam are then recovered on a magnetic drum, put through a wringer to squeeze out the oil, and returned to the hopper for reuse. Sea tests were called successful.

NOAA and USDA Team To Improve Crop Forecasts

A pilot project to improve the accuracy of agricultural crop forecasting throughout the Great Plains area of the United States is being conducted this summer by scientists from NOAA and the U.S. Department of Agriculture (USDA).

Personnel from NOAA's National Environmental Satellite Service and the USDA are seeking an improved method of determining how much solar energy is available to crops at any given time of a growing season.

Energy from the sun is vital to the growth of crops as a factor in photosynthesis and in evapotranspiration—the sum of water lost directly from the soil by evaporation and from plants by transpiration.

To forecast the crop yields accurately, agricultural specialists need to know a number of factors, including the amount of solar radiation; available moisture, including rainfall; and air temperatures for a given area.

While a scattered network of solar-radiation measuring devices, known as pyranometers, does exist throughout the Great Plains, it is considered too sparse to provide precise information in all areas of interest, according to the Great Plains Agricultural Council. Satellite imagery, it is hoped, would provide desired coverage.

Satellites operated by NOAA carry instruments capable of measuring the amount of cloud cover. The cloudiness indicated by the satellites will be related to the amount of sunlight measured at ground level by the pyranometers. To determine whether the readings are precise enough to meet the needs of the Great Plains Agricultural Council, the investigators will compare hourly readings from NOAA's GOES–1 geostationary satellite with measurements taken from a network of pyranometers.

New Instrument Pack Flown In Airlines Test

A Pan American World Airways Boeing 747, in regular passenger service for the international airline, is doing double duty as a flying laboratory, demonstrating the concept that aircraft can collect important weather information in flight and relay it via satellite to weather forecasters on the ground.

An electronics package which collects data from the aircraft's instruments is the heart of the joint program conducted by NOAA and the National Aeronautics and Space Administration (NASA).

The project is under the direction of NOAA's World Weather Program Office. James Giraytys of Environmental Monitoring and Predictions (EM) is the project manager, with Dr. James K. Sparkman, NOAA physical scientist, and Dr. Rex Fleming, director of the FGGE project office, working together with NASA to develop and implement the instrument package.

The package was developed for NOAA by NASA's Lewis Research Center, Cleveland, under the technical management of the Goddard Space Flight Center, Greenbelt, Md. It is designed to tap into the inertial navigation systems of wide-bodied 747 and DC–10 series jets, collecting data on the air temperature, wind direction and speed, aircraft location and altitude.

This material is automatically converted into a message format which is transmitted to a NOAA geostationary satellite for instantaneous retransmission to the ground.

Throughout this year, five more of the electronic packages are expected to be installed on aircraft operated by other international carriers. The packages are called Aircraft to Satellite Data Relay (ASDAR) platforms.

The prototype ASDAR model weighs about 40 pounds (18 kilograms) and is about the size of an electric typewriter. It requires about 200 watts of power, and transmits on a frequency of 401.7 megahertz.

The satellite which relays the message to the Weather Service through NOAA's Command and Data Acquisition Station at Wallops, Va., is one of two geostationary spacecraft NOAA operates. While their main use has been to provide images of the earth and its atmosphere—seen nightly on most TV weather broadcasts—they also each have the capability of handling messages from more than 10,000 data collection platforms; land-based, on ocean buoys, or, as in the case of ASDAR, aircraft aloft.

NOAA and NASA scientists see the major potential for the ASDAR system as providing meteorogical data from the tropics and southern hemisphere where weather information is particularly difficult to obtain. But the retrieved information also is considered valuable to airlines, providing up to the minute weather conditions for inclusion in last-minute flight planning, with resulting potential savings in fuel and flight time, as well as more accurate forecasts of importance in aircraft routing.

U.S. Coastal Zone Maps Published

A series of 11 coastal zone maps of U.S. areas, showing both the topography of the land and the bathymetry of the ocean and other water areas will be published jointly in the next 18 months by NOAA and the U.S. Geological Survey.

The series includes maps of the Houston and Bay City (Tex.) quadrangles; the Savannah and Brunswick (Ga.) quadrangles; and the Los Angeles, Monterey, Santa Ana, San Diego, Long Beach, Eureka and Smith River (Calif.) quandrangles.

The multi-color maps, commonly called "topo-bathy maps," are designed for use mainly by coastal zone planners and administrators as well as conservationists, environmentalists and others interested in programs, projects, and activities in coastal wetlands, on the Outer Continental Shelf (OCS) and in other coastal areas.

NMFS Observers Placed On Foreign Fishing Vessels

The first of an estimated 160 United States observers have been placed on foreign fishing vessels that are permitted to fish within the 200-mile fishery conservation zone.

Four observers from the National Marine Fisheries Service boarded two Japanese crab factory ships when the ships sailed from Hokkaido, Japan, bound for the Eastern Bering Sea. They will remain on the ships until the Japanese reach their quota of 12,500 metric tons of tanner crabs.

Under the terms of permits issued under the Fishery Conservation and Management Act of 1976, observers are placed on foreign fishing vessels information on the types of gear used as well as the fishing effort of the vessels. In addition, they will monitor compliance with the regulations and terms of the fishing permit.

Observers are scheduled to be placed on the fishing and processing vessels of Spain, Japan, Italy, East and West Germany, Taiwan, Poland, USSR, France, Romania, South Korea, and Bulgaria during those periods of the year and in the areas in which they have permission to fish.

U.S. observers will board the ships either before they leave their home ports, from Coast Guard vessels at sea, or when the foreign ships enter U.S. ports to pick up the observers.

noaa/update

Robert W. Schoning (center), director of National Marine Fisheries Service, and Howard Pollock (right), NOAA Deputy Administrator, are shown accepting a plaque from Al Guimond, Executive Secretary, Atlantic Offshore Fish and Lobster Association. The presentation was made to NMFS for the efforts of the Secretary of Commerce and NMFS on AOFLA's behalf during implementation of the Fishery Conservation and Management Act of 1976.

Fishery Conservation Act Report Summarizes Actions

Actions taken by the eight Regional Fishery Management Councils and the Department of Commerce to implement the Fishery Conservation and Management Act of 1976 are summarized in a report sent to Congress by the Department of Commerce.

The report covers the period during which preparations were made to insure that the United States would be prepared to exercise its management authority of the 200-mile limit on March 1, 1977. Members of the Councils were appointed in mid-August, began meeting in late September and early October, and by the end of the year had elected officers and, in many cases, had selected executive directors and administrative headquarters.

Scientific and statistical committees were established and the Councils began evaluating the fishery resources within their areas, and reviewed and provided comments on matters and documents associated with management of foreign fishing.

In addition to processing nominations for Council membership, conducting an orientation conference, and issuing regulations and an operations manual on Council activities, NMFS prepared 16 preliminary fishery management plans. The plans identified those portions of the optimum yields of fisheries that could be allotted to foreign fishermen.

Other major actions were undertaken with the cooperation of the Department of State and the U.S. Coast Guard. Six Governing International Fishery Agreements were signed and others were being negotiated by the end of the year. In addition, forms for foreign permits and permit applications were developed, a proposed fee schedule prepared and published, and enforcement and surveillance requirements assessed to insure compliance with the Act.

The activity report contains detailed information on actions taken regarding the formation of the Fishery Management Councils, fishery management, and inter-agency activities. It also discusses the accomplishments of the eight Regional Fishery Management Councils.

Waterspouts Subject to Aircraft Laser Probe

Laser probes of waterspouts, the mild oceanic cousins of tornadoes, indicate that some spouts may sometimes be two funnels, one inside the other, each rotating at its own speed.

Double-walled waterspouts were among the recently announced preliminary findings of a study begun last summer that probed the seagoing funnels off the Florida Keys with a laser beam aboard a small aircraft.

The laser is part of a novel instrument that ERL's Dr. Ronald Schwiesow and Richard Cupp, and Dr. Peter Sinclair of Colorado State University, used to measure wind speeds in waterspouts from Sinclair's Cessna 207.

Double-walled spouts have been observed before, according to Schwiesow, but their winds had not been measured until this study. "They were so named because of their appearance," he explained. "It was supposed that the double-funnel effect was caused by variations in moisture in the spout, with a visible 'wall' being formed simply by denser concentrations of water.

"But, because our laser device lets us measure wind speeds, we were able to identify the dynamic difference—a difference in velocities within the spout that indicates two cylinders rotating about a common axis."

Preliminary analysis of the data, he said, suggests that the two vortices of a double spout are in fact two separate, concentric funnels, which, while rotating in the same direction, rotate at different speeds.

Only part of the data has been analyzed, but the maximum rotational velocity they found so far was 56 miles (90 kilometers) per hour. Schwiesow emphasizes that as more of the data are analyzed, they will be able to tell whether that figure is typical. The waterspouts ranged in size from 13 feet (4 meters) to giants 100 feet (30 meters) across. All of them occurred at least seven miles (11 kilometers) from shore.

The researchers were also able to measure the turbulence on the upwind side of the waterspouts. This turbulence occurs, Schwiesow explained, because the waterspouts often move more slowly than the prevailing breeze. They had found this to be true of dust devils, as well. Such turbulence was expected from theory, but the NOAA team was able to document the actual quantity of the turbulence.

Additionally, Schiesow said, the team observed waterspouts rotating both clockwise and counter-clockwise, unlike tornadoes, most of which are counter-clockwise. Dust devils, he noted, are about evenly divided.

Shellfish Wastes To Be Recycled By SG Scientists

Shellfish wastes, now a disposal problem in seafood processors, may one day be the source of material to wrap food, heal wounds, strengthen paper and cloth, and bond paper, wood and leather.

The shells of shellfish contain chitin, a cellulose-like material with great commercial potential, according to Sea Grant researchers at the Massachusetts Institute of Technology. In addition to possible use in the food, medical and paper products industries, the material also can be used to remove radioactive heavy elements from nuclear power plant wastes and metal contaminants from drinking water.

Interest in chitin and chitosan, one of its derivatives, has taken on new dimensions recently as shellfish processors respond to regulations prohibiting the dumping of untreated shellfish waste in the sea.

Cdr. Robert A. Ganse, Chief Boatswain William Brooks, and Ens. S.P. DeBow, Jr. (left to right), of the National Ocean Survey's Rude/Heck, rig the recently acquired drag machinery for a final sweep of the James River near Hopewell, Va. The tanker Marine Floridian hit the north truss span of the Benjamin Harrison Bridge, which later collapsed. After a number of sweeps with the equipment (from the Royal Navy Hydrographic Division, Great Britain), the channel under the bridge was opened to unlimited river traffic.

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